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THE EFFECTS OF PROJECT LEAD THE WAY LAUNCH CURRICULUM ON ELEMENTARY GIRLS' PERCEPTION AND CAREER INTERESTS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

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THE EFFECTS OF PROJECT LEAD THE WAY LAUNCH CURRICULUM ON ELEMENTARY GIRLS' PERCEPTION AND CAREER INTERESTS IN STEM

A Dissertation

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

in

Educational Leadership

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by

Mina J. Blazy

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ABSTRACT

The United States has examined the quality of science, technology, engineering and mathematics (STEM) education since before the turn of the century. STEM educators are still having the conversation around why more women are not joining STEM pathways. Girls and boys as early as birth are curious about the world; through their own lens they learn about gravity from dropping spaghetti on the floor or seeing a small insect on the wall. As children get older they are influenced by the perceptions of their parents and peers.

This study looked at the perception and career interests of girls in STEM and non-STEM schools. Student surveys included the Career Interest Questionnaire (CIQ) and the Semantics survey. The CIQ asked participants about their interests in STEM careers and college, and the Survey items were designed to measure understanding how girls feel about STEM. The participants in the study were from the same school district. One group of participants was from a non-STEM school (i.e., an art magnet school), and the other group was from a STEM magnet school. All participants were females from grades 4 or 5. The STEM group of participants in the study had access to Project Lead the Way (PLTW) Launch curriculum designed for kindergarten through 5th grade. The STEM students had access to PLTW Launch curriculum beginning in kindergarten, and the other group in the study did not have access to PLTW Launch or other STEM curriculum.

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DEDICATION

I fully dedicate this dissertation to my family and the community where I live and work. You truly were a support for me on this journey.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

STEM Education is an acronym that has been used liberally over the past two decades. This term has different meanings for educators across the world (Bybee, 2013). From the definition of STEM to what it looks like in the classroom has been an ongoing conversation. It is clear that education calls for the integration of STEM disciplines with history, English and other academic content. With limited time during the school day, this is clearly a problem in education.

The California Department of Education (CDE) requires at least 180 days in a school year and establishes minimums for academic minutes during a typical school day (California Department of Education, n.d.a). There is no specific time set aside for any of the core subjects. This includes both mathematics and science. School sites and teachers determine how much time will be spent on mathematics and science education.

The integration of science, technology, engineering and mathematics (STEM) was considered important among leaders in these fields (Bybee, 2013). Initially, the acronym STEM was more of a slogan that educators embraced without a clear definition (Angier, 2010; Keefe, 2010). At federal and state levels there are policies that describe STEM education. However, federal, state and local levels have different definitions of what STEM education looks like within schools. What is agreed upon is that students need access to STEM education that will provide core competencies they will need as adults (Bybee, 1993, 2013; *STEM Integration in K-12 Education*, 2014). Bybee (2013) noted that a proposed purpose for “STEM education is for all students to learn to apply basic content and practices of the STEM disciplines to situations they encounter in life” (p. 5). STEM education is also defined as the interconnectedness between the disciplines to develop problem solving skills and beliefs about STEM learning (Baran, Bilici, Mesutoglu, & Ocak, 2016).

The four STEM disciplines (science, technology, engineering, and mathematics) are to be learned in full integration, as industry in the real world does not isolate these disciplines. STEM learning is an integrated approach and should be applied with authentic world issues using problem-based learning (Bybee, 2013; Lou, Tsai, Tseng, & Shih, 2014; *STEM 2026*, 2016). STEM education integrates the four disciplines through cohesive and active teaching and learning approaches (Beede et al., 2011; Innovate, 2014, p. 7). The task force for STEM education in California provided a blueprint for the STEM disciplines for k-12 education (Innovate, 2014, p. 7)

> Science is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, and conventions associated with these disciplines. Technology comprises the entire system of people and organizations, knowledge processes, and devices that go into creating and operating technological artifacts…which are a product of science and

> engineering. Engineering is both a both a body of knowledge—about the design and creation of human-made products—and a process for solving problems. This process is design under constraint. One constraint…is the laws of nature. Other constraints include time, money, available materials, ergonomics, environmental regulations, manufacturability, and reparability. Mathematics is the study of patterns and relationships among quantities, numbers, and space…claims in mathematics are warranted through logical arguments based on foundational assumptions.

To the definition of STEM, the Economics and Statistics Administration (ESA) added physical and life science, mathematics, engineering, computer science and ‘support jobs’ that are technical in nature (Beede et al., 2011).

The goal of *STEM 2026*, *A Vision for Innovation in STEM Education* (U.S. Department of Education, 2016) is to give all students equitable access to STEM learning (Council, 2013; Honey, Pearson, & Schweingruber, 2014; Tannenbaum, 2016). This vision includes giving socio-economically disadvantaged students the ability to increase their digital literacy with STEM integration. Students benefit from STEM integration by relating themes and patterns across the disciplines allowing students to take learned information in one discipline making connections fluidly between disciplines (Council, 2013; Honey et al., 2014; Innovate, 2014; P2015; Tannenbaum, 2016).

The California Department of Education’s Curriculum and Instruction recommendations list English language arts, mathematics, history, science and physical education as areas that students are to master by the end of a given grade level (California Department of Education, n.d.b). Although the current science curriculum is based on the Next Generation Science Standards (NGSS) little time is given to science teaching. Many teachers demonstrate a paucity of knowledge in this area and don't feel confident in teaching the NGSS framework. Students are at the mercy of the teacher who emphasize mostly the curriculum he or she feels comfortable teaching (Tannenbaum, 2016).

There is also the assumption by many educators that subjects are isolated in their discipline and separated from STEM. For example, if an educator teaches history, they may not see the relevance of integrating science. Also, some veteran teachers may not have the requisite skills to incorporate STEM (Bybee, 2013; Honey et al., 2014; Innovate, 2014). Focusing only on facts in education does not allow for learning skills that are integrative or for problem solving; skills that are needed to have a scientifically literate society (Bybee, 1993, 1997, 2013; Innovate, 2014; Marcus, 1994).

Policy makers at federal, state and local levels have different perspectives on what STEM should look like in K-12 and higher education (Bybee, 2013; Innovate, 2014; Marcus, 1994; US Department of Education, 2016). The US Department of Education position on STEM education has a clear focus on how to include girls in STEM and continue to provide equitable access. The California Department of Education, however, discuss equity but does not elaborate on how to include girls in STEM (Innovate, 2014; Tannenbaum, 2016).

Giving a voice to women in STEM has its challenges. There are implicit and explicit biases that include historical stereotypes, gender stereotypes, and a gap in the number of women in STEM careers compared to men (Beede et al., 2011; Bybee, 2013; Cooper & Heaverlo, 2013).

Women and girls have their own perspectives on what STEM education and STEM careers look like in the world. In the early grades, both girls and boys have similar perceptions in mathematics and science from birth until about first grade (Eccles et al., 1993; Eccles & Wigfield, 1993). Children in elementary school are overly optimistic in their perceptions, values and interests and tend to decline at the beginning of middle school age (Eccles et al., 1993). Gender stereotypes tend to take hold of perceptions for both male and female in domains such as science, mathematics, English and sports (Jcobs, Lanza, Osgood, Eccles, & Wigfield, 2002). This becomes a disadvantage for women and girls in STEM (Beede et al., 2011; Harding, 1986).

There are still areas where boys and girls take on societal roles in mathematics and science (Jacobs et al., 2002). Children learn and form identities from an early age; starting with their parents, their community environments, and from their classroom teachers (Archer et al., 2012; Brickhouse & Potter, 2002). This happens because of parent, peer, curriculum and classroom experiences that influence the dominant cultures roles for both women and men (Jacobs et al., 2002; Wigfield & Harold, 1997). Science or engineering identities are a social construct that shapes the way children see themselves in schools (Brickhouse & Potter, 2002). Gender biases continue throughout their academic careers and into their professional careers (Archer et al., 2012; Cundiff, Vescio, Loken, & Lo, 2013).

A consequence of female gender biases and stereotypes in STEM causes women to be less likely to pursue and persist in STEM fields. The phenomena of women not entering STEM fields, or leaving STEM fields, is called the *STEM leaky pipeline* (Blickenstaff, 2005). Women leak out of the pipeline at various stages in their pursuit in STEM professions. These women show interest in STEM in elementary school but start dropping out of STEM disciplines in middle and high school or choose a major in college outside of STEM. Occasionally, women start out in STEM majors and change their minds in college, and some women graduate with STEM degrees and choose a career entirely out of their professional degree. Also, the majority of role models for science and mathematics are male. The result is a sex based filter that has more men than women at the end of the pipeline (Blickenstaff, 2005; Lyon, Jafri, & St. Louis, 2012). The dominant male culture promotes this sex based filter as there are still more men than women in STEM careers.

Table 1.1 shows the outcome of the problem. In Table 1.1, the data show that there is a slight gap between all jobs for males and females compared to a large gap between STEM jobs held for males and females.

Table 1.1. United States Job Comparison in all Jobs and STEM Jobs by Gender

Gender	2009 All Jobs	2009 STEM Jobs	2011 All Jobs	2011 STEM Jobs	2015 All Jobs	2015 STEM Jobs
Female	48%	24%	48%	24%	47%	24%
Male	52%	76%	52%	76%	53%	76%

Note. (Beede et al., 2011; Noonan, 2017; Ornes, n.d.)

Table 1.1 shows that the number of males and females is almost equal in all jobs in the United States, but in STEM jobs men hold 76% of the jobs compared to women holding 24% of STEM jobs. From 2009 to 2015, *all jobs* shifted by 1%, but STEM jobs did not budge.

Background

Before 1957, the United States assumed they led the world in science and mathematics. With large amounts of funding from the federal government, NASA worked on sending a rocket into orbit at the same time that Russia was working on their expedited Sputnik launch. Because the US fell behind in science and mathematics, the National Defense Education Act (NDEA) was created to support science and mathematics education in schools. However, the NDEA did not account for the shortage of women in science and mathematics. Even though President Truman, in 1951, believed that education in science and mathematics should be available to women and minorities, this was not readily addressed until the landmark reports *A Nation at Risk* and *Rising above the Gathering Storm* (Johanningmeier, 2010; Rising Above the Gathering Storm Committee (US), 2010; United States National Commission on Excellence in Education, 1983).

There is a substantial bias when it comes to women in STEM education and STEM career pathways. Women and girls develop their career and educational aspirations over time. The STEM stereotypes that are learned happen at several stages in girls' lives. Women's identify in science is positive in their primary school years and tend decline as they enter into middle and high school (Settles, Jellison, & Pratt-Hyatt, 2009) Students sometimes get their science identities from their experiences with teachers and their parents belief about science (Blickenstaff, 2005, Cundiff et al., 2013; Piatek-Jimenez, 2008). Both girls and boys inherit the role that a teacher portrays on the student (Blickenstaff, 2005). A student's experiences include STEM stereotypes that begin to influence them around the age of seven or by second grade (Cundiff et al., 2013; Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006).

Problem Statement

STEM education is not consistent across elementary, middle and high schools. Data collection for science and mathematics are collected differently; lack progress monitoring, instruction with fidelity and inequitable programs are a hindrance of quality education with consistency (Innovate, 2014). Furthermore, here are limited curricula to support connections between the disciplines of STEM. Even with the adoption of the Next Generation Science Standards (NGSS), most curricula being used in public schools are old and outdated. Current curricula are largely based on the previous science framework. The NGSS was adopted in California in the fall of 2013, and the rollout of the standards started in 2016 with Phase IV in 2017 (*NGSS California*, 2013). The department of Education in the State of California choses curricula in science, mathematics, social studies and English language arts; then each district can choose from the list of approved curricula adoptions (Bybee, 2013; *California NGSS Adoption*, 2013.; *NGSS California*, 2013). This can be a long process and take at least a year for the state level adoption process to be complete. Even after the list is approved stakeholders from school districts peruse through curriculum before it is sent to the district's board of education for approval. Currently school districts are still choosing science and engineering curriculum that aligns with NGSS. It has been frustrating for teachers without access to curricula that are well aligned to the standards; in short, teachers lack appropriate curricular resources such as textbooks, consumables, and activity-based materials. A natural consequence is that many elementary teachers do not integrate STEM into the school day either from a lack of resources, experience, or the stance that there is not enough time in the school day to teach these subjects (Stine, 2008).

Furthermore, the extant curriculum being implemented is replete with gender stereotypes. School districts and teachers are not able to battle the stereotypes that are present in the curriculum because it is ubiquitous. Females are being left behind their male counterparts because of the outdated mindsets in the curriculum. Girls still have to navigate through gender stereotypes.

Girls have a disadvantage from an early age, and by the time they reach middle school there is a loss of self-efficacy in STEM (Bandura, 1993; Blickenstaff, 2005; Greenwald et al., 2002; Silvia, 2003; Wang, 2013). In turn, women's perspectives are being missed because of the lack of women in STEM careers. Gifted women are not able to reach their fullest potential based on gender stereotypes (Lupart, Cannon, & Telfer, 2004). At this time there are also not enough studies that document elementary girls' perceptions about careers in STEM, their self-efficacy, perceptions and interests in STEM education.

Purpose Statement

The purpose of this study was to compare the perceptions and career interests of girls that had access to the Project Lead the Way, Launch curriculum in elementary school and girls that did not have similar access. It is important to focus on girls' perceptions and career interest and to exam if they are different based on the type of curricula they experience. The focus group of participants in the study will have had at least four years of experience, from kindergarten to fourth grade or kindergarten through fifth grade, with the PLTW Launch curriculum.

A second purpose of this study is to determine if there is an increased level of perception and/or career interest among girls with access to STEM curricula in elementary school, compared to girls who have not been exposed to STEM in elementary. A safe environment for girls in the classroom can be provided when the experience of girls is acknowledged and equitable curricula are available (Mayberry & Rees, 1997).

This study will bring to the surface whether girls who have access to STEM curriculum at the elementary level will have a positive perception of their own self-efficacy in STEM and if the girls will see themselves as future STEM figures. At this time there are few schools in the United States that offer STEM curriculum starting at kindergarten (Innovate, 2014; PLTW, 2017).

Project Lead the Way (PLTW) is an enrichment STEM curriculum that offers the Next Generation Science Standards together with activity-problem based learning model with real world activities for students to work through in a collaborative environment (PLTW, 2017). PLTW was also the curriculum that is be used in K-5 classrooms at the STEM school in the study.

During the 2018-2019 school year there were a total of 6,220,413 students in the California K-12 school system. Of these, 3,048,199 students were in the 5,873 elementary schools in California. During the 2018-2019 school year, there were about 380 elementary schools, or 6% of elementary schools in California, that used PLTW Launch as their elementary STEM enrichment curriculum (PLTW, 2019b). The main purpose of the study is to find out if PLTW's Launch elementary curriculum gives girls and advantage in their perception of STEM and an increase in career interest in STEM. At this time there is a lack of research in the perceptions of girls in STEM, and there is no research that correlates with PLTW Launch elementary curriculum and the self-efficacy, STEM interests, and perceptions of girls in STEM.

Research Questions and Hypotheses

1. **Research Question 1:** What is the correlation between STEM perceptions and STEM career interests for the STEM (r_S) and non-STEM (r_{NS}) school girls'? More specifically, are the correlations between STEM perceptions and STEM career interests for the two groups equal?

   $H_{0}1$: $\rho_S = \rho_{NS}$

   This null hypothesis states that there is no difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

   $H_{1}1$: $\rho_S \neq \rho_{NS}$.

The alternative hypothesis states that there is a difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

2. **Research Question 2:** What is the difference in means between STEM perceptions of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls who had no exposure to the STEM PLTW Launch Curriculum?

   H_{02}: $\mu_S - \mu_{NS} = 0$

   There is no difference in the population means in STEM perception for STEM and non-STEM students for the two groups.

   H_{12}: $\mu_S - \mu_{NS} \neq 0$.

   There is a difference in the population means in STEM perception for STEM and non-STEM students.

3. **Research Question 3**: What is the difference in means between STEM career interests of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that had no exposure to the STEM, PLTW Launch curriculum?

   H_{03}: $\mu_S - \mu_{NS} = 0$

   There is no difference in the population means in STEM careers for STEM and non-STEM students.

   H_{13}: $\mu_S - \mu_{NS}. \neq 0$

There is a difference in the population means in STEM careers for STEM and non-STEM students.

Significance of the Study

The significance of the study is the knowledge gained about elementary girls' perceptions and self-efficacy at an age when change can occur. Girls' attitudes toward STEM begin at a young age. When girls are targeted with early STEM intervention, it is likely to influence them in later years to participate in STEM careers (Salmon et al., 2015). The study will help support the claim of the relationships between the experiences and perceptions. Girls who engage in STEM related activities have positive perceptions regarding STEM and have higher career interests in STEM fields.

Theoretical Underpinnings

The theoretical underpinnings are intertwined with theories of feminism, self-efficacy and STEM education (Ellemers & Haslam, 2011; Harding, 1996, 2016; Harding, 1986). There is still evidence that male stereotypes exist in curriculum, K-12 school environments, higher education environments and careers (Blickenstaff, 2005; Greenwald et al., 2002). It is evident that women lag behind their male counterparts in science, technology, engineering and mathematics even though there have been several advances to women's rights since the nineteenth century (Connell, 2005; Harding, 1986; Luttrell, 1990). Even though there are more girls in advanced placement science courses, their perception, self-efficacy and desire to go into STEM fields are lower than boys (Brickhouse & Potter, 2002; Jolly, 2009). Educators are teaching STEM course work to males and females equally. Equal is not equity! It is presumptuous to assume that equal learning is what students need. Still, we know that the United States is founded on political and Western discourse that gives masculinity the ability to marginalize feminism and continue with social stereotypes after women leave the K-12 science classroom (Brickhouse & Potter, 2002; Harding, 1986).

Women have offered and have the capacity to offer a unique contribution to science and must challenge the masculine bias towards science (Intemann, 2010). The gender inequality continues because men hold the power and the resources to make the change. Men have a role and must be involved in the resolution of not keeping women in impoverished academics (Connell, 2005; Harding, 1986; Luttrell, 1990). When girls develop their own cognitive abilities in a specific domain they are more likely to create goals that will come to fruition (Bandura, 1993).

Assumptions

It is assumed that answers students give on the surveys will be authentic. Demographic data will be pulled from California Dataquest for each school site. It is assumed that these demographic data are correct. The assumption is that the students have access to the PLTW Launch curriculum at the STEM school and the students at the non-STEM school do not have a STEM curriculum, and that teachers do not teach an integrated model of STEM. Since science and mathematics are part of the regular curriculum, it is assumed that teachers in the study will be including mathematics and science learning experiences for all children at their respective school sites.

Delimitations

This research is restricted to only using the PLTW Launch elementary curriculum as an operational way for defining STEM education. The study will not look at other STEM enrichment programs in the state of California. The girls that will take the survey will be from 4th and 5th grades. Teacher information and data will not be part of the research.

Definitions of Key Terms

<u>APBL.</u> Activity problem-based learning

<u>Design process for engineering.</u> Ask, explore, model, evaluate and explain

<u>Domain.</u> An area of interest such as science, engineering, art, technology, language, etc.

<u>Engineering fields.</u> Engineering fields refers to civil, chemical, bio-medical, robotics and other types of engineering

<u>Feminist classroom.</u> Feminist classroom refers to collaboration and a non-hierarchical ethos, discussion rather than all lecture. There could be a

balance between lecture and discussion. "Equity and collaboration as hallmarks" (Seymour, 2007) in the classroom. Three themes: Resisting Hierarchy, using experience as resource and transformative learning. (*Feminist Pedagogy – GEA– Gender and Education Association*, n.d.)

Gender inequality. Gender inequality refers to unequal treatment or perceptions of individuals based on their gender.

Gender gap. Gender gap refers to the discrepancy in opportunities, status, attitudes, etc., between men and women (Blickenstaff, 2005).

Leaky pipeline. Leaky pipeline is "a metaphor frequently use to describe the fact that women are under-represented in STEM careers… carrying student from secondary school through university and on to a job in STEM." (Blickenstaff, 2005, p. 369)

PBL. Problem-based and Project based learning

PLTW. Project Lead the Way initiative in STEM curriculum and supporting K-12 students in having access to STEM informational text and activity problem-based learning

Pre-adolescent. Pre-adolescents are children age 8-11 years old

STEM. STEM stands for science, technology, engineering and mathematics (*United States Department of Commerce. Bureau of the Census, San Bernardino*, n.d.)

STEM fields. STEM fields refers to biology, chemistry, computer science, engineering, geology, mathematics, physics, social and behavioral science

Summary

Children do not just grow up to be scientists or engineers without a perceived notion that this is possible. Girls especially do not attempt to go into STEM careers because the STEM job track lacks the ability to increase girls' perceptions of STEM (Lamb, Akmal, & Petrie, 2015). This study attempted to show relevant information on the self-efficacy, perceptions and career interests of girls with regards to their beliefs in STEM as early as elementary school. Historically, girls are less likely to choose a career in STEM. Even if they choose STEM in college, women tend to leave the STEM pipeline. Girls' self-efficacy in STEM is equal to boys as young as first grade until about age 10 (Jacobs et al., 2002; Lamb et al., 2015, Shaprio et al., 2015). Instead of focusing only focusing on girls' self-efficacy in middle and high school it is projected that girls who are exposed to relevant STEM curriculum at a younger age will increase perceptions, self-efficacy and interests in STEM (Lamb et al., 2015).

The next section, chapter two, is a summary an analysis of literature of STEM education in the US, the state educational standards, the leaky pipeline for girls in STEM, underrepresentation of women in STEM, self-efficacy in STEM, STEM stereotypes, career self-efficacy and history of PLTW. The literature review sets the foundation for the research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Policies across the US have created initiatives on the education effect of STEM. The history of STEM, with policy researchers, has made efforts over time to impact underrepresented women in STEM. Still there is a gap in why girls choose not to enter STEM fields even with the influence of *A Nation at Risk*, the US Department of Education, and the National Defense Education Act. The following literature review is a sequential background of where we started to where we are now in STEM education, STEM perceptions and STEM careers in the US.

STEM Education in the United States

The Soviet Union shocked the United States by being the first country to launch a successful satellite into orbit. On October 4, 1957, Sputnik was launched into space by the Soviet Union. The Sputnik satellite was no larger than a 23 inches ball in diameter (Jolly, 2009). This satellite was the first artificial intelligence (AI) sent outside of our atmosphere to orbit the Earth (Dickson, 2001).

The US failed to be the first country in space after it was stunned by the Soviet Union's Sputnik (Dickson, 2001). This stirred up conversation and action to increase science and mathematics education in the US. Not only did the U.S. have plans to increase science awareness through International Geophysical Year (IGY) project, but during the 1940s and 1950s the nation's education critics believed that schools did not hold the same educational rigor that was needed to sustain world competitiveness (Johanningmeier, 2010). From President Truman's second term in office to President Carter, there was a sense of urgency to create science and engineering literate students that could compete with a global economy. In the 1980s, *A Nation at Risk* was introduced stating that America was still behind education (United States National Commission on Excellence in Education, 1983). The findings listed that American students were not enrolling in advanced placement courses, spending less time in the classroom, and falling short of enrolling in higher mathematics like calculus (Johanningmeier, 2010; United States National Commission on Excellence in Education, 1983). The content recommendations in *A Nation at Risk* were to have students complete four years of English, three years of mathematics, three years of history, three years of science, and two years of foreign language; both high schools and universities were tasked with creating more rigorous standards and increased expectations in academics and college admission requirements (United States National Commission on Excellence in Education, 1983, pp. 60–70). The school day recommendations were a minimum of 200 days with an 11 month teacher contract to allow for school preparation (United States National Commission on Excellence in Education, 1983).

In addition to the recommendations in *A Nation at Risk*, several agencies created documents that called for reform. These included the Commission on Higher Education, the *Brown* decision of 1954 (*Brown v. Board of Education*, 1954), the Committee on Education Beyond the High School (Bybee, 2013), and the National Science Foundation (NSF). All were consistent with the Department of Education's increased need for student access to both engineering and science (United States National Commission on Excellence in Education, 1983) expressed in *A Nation at Risk.* With little change for over 60 years, we continue to look at science and mathematics initiatives in the US (Dickson, 2001; Johanningmeier, 2010; Urban, 2010).

Since President Eisenhower, researchers also believed that it was a waste to not have the voice and brainpower of women and minorities within the science and engineering fields (Johanningmeier, 2010; United States National Commission on Excellence in Education, 1983). As early as 1951, under President Truman's leadership, it was believed that the resources needed should be used to give students access to science and give voice to minorities and women in science and engineering (Johanningmeier, 2010).

The Sputnik era of the 1950s influenced the development of new science and mathematics programs (Bybee, 1997). Program and product such as the Chemical Bond Approach (CBA), the Science Curriculum Improvement Study (SCIS), the Chemical Education Materials Study (CHEM), the Biological Sciences Curricula Study (BSCS), the School Mathematics Study Group

(SMSG), the Greater Cleveland Mathematics Program (GCMP), the University of Illinois Arithmetic Project, the University of Illinois Committee on School Mathematics (UICSM) and the late entry of Engineering Concepts of Curriculum Project (ECCP) were created in the late 1950s through the late 1960s. The development of these programs followed the success of Sputnik (Bybee, 2013; Johanningmeier, 2010). All of these programs contributed to the nation's science and/or mathematics standards and curriculum. The UICSM, for example, worked on curriculum that would look at theory and apply mathematics to real world initiatives, not just computation (Johanningmeier, 2010). The SCIS started in the early 1960s as a curriculum for students to use real phenomena with exposure to hands-on science activities in elementary school (Karplus, 1964, 1967).

The role of the federal government from 1953 to 1961 was to replace the existing curricula and increase economic support in education (Bybee, 2013). The National Defense Education Act (NDEA) infused a billion dollars over a four-year period to stimulate American's talent; this included student loans, scholarships, and fellowships for graduate students. The NDEA wanted to be sure that the US stayed competitive in science and mathematics. High-achieving students in grades 9 through 12 could be part of PROJECT Talent if they passed an aptitude test. These high-achieving students were also offered an accelerated path for STEM careers. The NDEA did not just want the gifted and talented to have access. Students who were high achievers, male, and interested in STEM would be included in the NDEA's STEM initiative

(Johanningmeier, 2010; Jolly, 2009). Student loans would be available, giving students who couldn't afford college the same opportunity as those that could (Jolly, 2009).

By the 1960s, NDEA afforded both teachers and researchers the opportunity to work together in a collaborative effort to increase STEM awareness, improve teacher professional development, and strengthen academic achievement in middle and high school (Jolly, 2009; *STEM Integration in K-12 Education*, 2014). It was reported that the new curricula made an impact on education with more than 60% of school districts using federal programs in grades 7 through 12 and about 30% of elementary school districts using at least one federally funded program by the 1970s (Weiss, 1978).

The National Defense Education Act (NDEA) allowed for a change in the way we looked at science and mathematics as a country. More students had access to rigorous coursework and curriculum. The argument for the exposure of science earlier in a child's education now was at the forefront of educational policy (Jolly, 2009). Now, elementary students would have access to science projects and real-world scientific phenomena (Anderson, 1961; Jolly, 2009).

Moving forward to 2005, the National Academies was tasked to look at the United States' competitiveness based on the global market place which resulted in that 500 page document, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Rising Above the Gathering Storm Committee (US), 2010). The *Gathering Storm* (Landers, 2010), as it became known, was making progress by changing legislation to support STEM education. However, revisiting the proposed *Gathering Storm* declared that the United States has made little progress (Landers, 2010). The funding for this program was not as available as the federal government promised.

Most of the original members of the team that created *Gathering Storm* were called together by the National Academy of Sciences (NAS) and the Institute of Medicine and the National academy of Engineering (NAE). Even the America Competes Act was revisited; their conclusion was the nation's improvement in preparing America to be competitive was in danger (Jolly, 2009; Landers, 2010). At this point the team believed the country was at a stand-still because of the availability of federal funding. The committee believed the *Gathering Storm* was a Category 5 hurricane, and if the United States, was to be competitive in the world, stakeholders such as "political leaders, educators, the business community and others" (Landers, 2010, p. 61) needed to revisit the report and work towards implementation. A few of the *Gathering Storm* recommendations were as follows:

- Increase the talent pool in science, math and technology improving K-12 by the recruitment of 10,000 new science and math teachers with competitive scholarships with a 5-year commitment to teach in public schools
- Increase the number of students in Advanced Placement in science and mathematics

- Strengthening the skills of 250,000 current teachers through funded training and master's programs, summer institutes and Advanced Placement training programs
- Increase federal investment in research by 10% per year over seven years, with a primary attention devoted to physical sciences, engineering, mathematics and information sciences—without disinvesting in the health and biological sciences.
- Providing research grants
- Establishing 25,000 competitive science, mathematics, engineering and technology undergraduate scholarships and 5,000 graduate fellowships in areas of national need for US citizens pursing study at US Universities
- Providing a federal tax credit to employers to encourage their support of continuing education
- Instituting a skill-based preferential immigration option.

  (Medicine et al., 2007, pp. 9–10)

The America Competes Act was passed by Congress on August 2, 2007 (Stine, 2008). One of the initiatives was "the nation's investment in science and engineering research and in STEM education from kindergarten to graduate school and postdoctoral education" with the focus in being competitive in research the number of students that are proficient in STEM and STEM careers (Stine, 2008, p. 6). The America Competes Act included:

- Creating and improving STEM high schools
- Hands-on and experience-based learning opportunities at the Department of Education's (DOE) national labs
- A high need public high school that will have access to the DOE national lab
- A new Director of STEM Education at the Department of Energy as the liaison for K-12 STEM Education
- Math Now would give teachers access to research-based professional development and tools to enhance elementary and middle school students' achievement in mathematics
- Training for teachers in Advanced Placement/International Baccalaureate (AP/IB) to improve education in low-income areas.

(Stine, 2008, pp. 28–30)

The America Competes Act was reauthorized in December 2010 and expired in October 2013. This Act was to invest in Americans to become scholars in STEM and to be competitive around the world (Augustine & Lane, 2014). As of 2013, we still found ourselves struggling in K-12 STEM education. The America Competes Act stated that the federal government would improve and increase its recruiting capabilities for women and underrepresented minorities in STEM education (Stine, 2008). However, we also still struggle in the area of women and minorities in STEM (Beede et al., 2011).

It is apparent that the America Competes Act of 2007 focused highly on middle and high school STEM. While the ACT mentioned K-12 education throughout, there is little that deals with an action statement in STEM (Augustine & Lane, 2014; Stine, 2008). The exception is the Math Now initiative for elementary education (Augustine & Lane, 2014; Stine, 2008). Both *Gathering Storm* and ACT noted that women needed to have a voice in STEM (Johanningmeier, 2010; Landers, 2010; Stine, 2008). Still the problem exists that women are not staying in the STEM pipeline at the same rate as their male counterparts (Agee & Li, 2018; Blickenstaff, 2005; Chesler et al., 2010; Goulden et al., 2011).

The Obama administration put forth an effort to include STEM education starting from preschool through higher education (Dickman et al., 2009; Sharp, 2016). STEM is still at the forefront of education with the idea that the STEM initiative would give children access to college and career (*CCSS California*, 2013; Hill et al., 2015; *NGSS California*, 2013). Within the United States Department of Education, the initiative stated that our world calls for student to be well versed in solving difficult problems, making sense of new knowledge, and being able to use evidence to argue and evaluate real world issues (*STEM 2026*, 2016). Students in elementary school who have a firm grasp in STEM not only have knowledge in STEM, also are able to access this information and use it to problem solve.

It was noted that beginning in 2015, students with a strong background in STEM would be highly sought after as there would be over 1.6 million jobs available in STEM areas (*Change the Equation*, 2015).

STEM in California

Over the past decade, the California Department of Education (CDE) has been working towards making STEM accessible for K-12 students. The vision for STEM in the state of California is "California leads the world in STEM education, inspiring and preparing all of its students to seize the opportunities of the global society through innovation, inquiry, collaboration, and creative problem solving" (Innovate, 2014, p. 5). California Superintendent of Public Education Tom Torlakson and California Assemblywoman Susan Bonilla worked with a task force to form this new vision of STEM education in California. The task force included K-12 administrators, teachers, company partners, and university leaders. The objective was to give California students their best chance of success in STEM careers by improving STEM education through professional development for educators, student learning, and career courses in STEM. The task force recommendations included "public awareness, resources, access, framework, professional development, assessment and accountability and guarantee the availability of high quality STEM education materials and resources" (Innovate, 2014, p. 6). The task force stated that giving K-12 students access to STEM education would not only improve their career interests but would also increase their problem solving, collaboration skills, and inquiry skills.

The CDE task force noted that K12 educators needed access to STEM professional development (PD). STEM PD would include “subject matter knowledge (SMK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK)” (Zeidler, 2002, p. 1). Unfortunately, over the past decade professional learning has decreased in the state of California in many school districts. Funding has also decreased that would allow districts and school sites to continue their professional growth (Innovate, 2014). According to the National Research Council (2011), elementary students across the nation decreased their science instruction by at least one hour, and both teacher and principals agreed that elementary children received low quality science instruction (Innovate, 2014). In K-5 schools, only 40% of students received an hour of science instruction per week, and administrators and teachers had less access to science PD (Dorph et al., 2011).

The factors that shape and influence science learning are teachers’ knowledge, materials for instruction and student assessments (Dorph et al., 2011). This study pointed out that most teachers felt confident teaching mathematics and English, but only about a third of teachers felt they had the background and support to teach science effectively (Piatek-Jimenez, 2008; Piatek-Jimenez et al., 2018). Teachers report not having access to equipment for hands-on science lessons and facilities that don’t allow for the instruction. California Administrators point out that the state test does not encapsulate all the standards, and there is little district or site level student progress monitoring

(Dorph et al., 2011). This information sheds light on the education in science for elementary students in the state of California.

California State Standards

In 2010 the state board of California adopted the Common Core State Standards (CCSS) in English/language arts (ELA) and mathematics for grade K-12. The ELA standards are separated into reading, writing, speaking, and listening and language. Mathematics K-6 has a minimum five domains starting with counting and cardinality, operations and algebraic thinking, number and operations in base ten, number and operations-fractions, measurement and data, geometry, the number system, and statistics and probability. After grade 6, districts can choose traditional mathematics or an integrated approach. Included in the CCSS for mathematics are the Standards for Mathematical Practice (SMP) (*SMPs*, n.d.). These practices are actions needed for implementation of the CCSS in mathematics. Forty-four states since 2010 have adopted CCSS and with the consistency students will learn standards at specific grade levels. If students move to other schools or states that employ CCSS, they will stay in stride with their learning objectives.

California Senate Bill 300 (2011) called for an overhaul of science standards. The former science standards framework was not fluid with other states, nor did standards consistently provide real-world phenomena. Because of the lack of real-world consistency, the state of California adopted the Next Generation Science Standards (NGSS) in 2013. The NGSS standards consist of three dimensions: 1) science and engineering practices (SEP), 2) crosscutting concepts (CCC), and 3) disciplinary core ideas (DCI) through applied real-world phenomena (*NGSS California*, 2013). Each grade K-12 has performance expectations, SEPs, CCCs, DCIs, aligned to both CCSS in ELA and mathematics, and can be viewed either by storyline or the observable outcomes that students will master by the end of the grade level.

The NGSS was influenced by the NSES and the NRC on its continued efforts to improve equity and diversity (*NGSS California, 2013).* Still the nation has a gap in learning in science education and an even further gap in science with regards to minorities and women. NGSS stated that there were three main areas found in their literature findings that will impact girls and increase their affinity and confidence in science:

> (1) instructional strategies to increase girls' science achievement and their intentions to continue studies in science, (2) curricula to improve girls' achievement and confidence in science by promoting images of successful females in science, and (3) classrooms' and schools' organizational structure in ways that benefit girls in science.
> (*NGSS California, 2013*)

NGSS provides at least one case study that steers educators into giving girls access to STEM. In 2015, according to the National Assessment of Educational Progress (NAEP), there was a gap in science performance between male to female for grades 8 and 12; however, interestingly there was little to no academic gap in grade 4. The assessment in science for grade 4 in 2009 had a one-point gap, there were no test results reported in 2011 and no gap in 2015. In 2009, there was a four-point gap at the eighth-grade level, and in 2011 a five-point gap at the same grade level. These gaps between male and female were statistically significant ($p<.05$). There was a three-point gap between male and female in 2015 and a six-point gap in 2009 with no test for 2011 (*NAEP Nations Report Card - National Assessment of Educational Progress - NAEP*, 2018). According to NAEP (2018), there was still a gap between male and female students in middle and high school, but there is no gap in fourth grade.

Leaky Pipeline

The STEM *leaky pipeline* is a metaphor to describe the under-representation of women in STEM. Women are also more likely to leave STEM compared to men (Beede et al., 2011; Blickenstaff, 2005).

This pipeline is a sex-based filter. One sex leaves the pipeline where one arrives at the end. This is not necessarily a conscious process, but it results in a gender imbalance in STEM fields. Peer related stereotypes still influence both genders to take on traditional gender careers (Shapiro et al., 2015). The pipeline starts when children are introduced to STEM concepts by their parents, by teachers in their elementary, middle, high school and higher education, and in their careers. According to Blickentstaff (2005), the absence of women in STEM got worse the farther down the pipeline students are; this was true even with progressive treatments/interventions.

Blickenstaff (2005) identified three reasons why there should be more women in STEM: (1) equity and access, (2) a large number of intelligent women are choosing other areas of work when they could be contributing to STEM, and (3) improvements with diversity in perspectives may offer “knowledge and solutions to human problems” that have not yet been tapped into (Blickenstaff, 2005, p. 370).

Blickenstaff (2005) explored other studies to identify why women leave the STEM pipeline. The paper suggests that science itself plays a role in removal of women, and some research studies are “without merit and in fact dangerous” (Blickenstaff, 2005, p. 369). He points out that other scientists actually focused their studies on the size of limbs, muscle mass and head size of both men and women (Hyde, 1991; Hyde & Linn, 2006). The size of the brain was said to be compared to the size of the head and that women’s brains were inferior to men’s brains. Women’s heads were even compared to gorillas Sadker & Sadker, 2010).

Scholarly literature includes research regarding gender differences in testing (Cole, 1997), cognitive and psychological abilities (Hyde, 1991) and attitudes (Blickenstaff, 2005). Cole (1997) analyzed more than 400 aptitude tests, assessments from NAEP, Medical College Admission Test, and Law School Admission Tests. The outcomes showed evidence that girls were better in writing, and boys were better in engineering subjects. Between grades 8 and 12, males' performance in both mathematics and science continued to increase, where females continued their advantage in language in these same grades (Cole, 1997). Cole's (1997) review of data from the Educational Testing Services (ETS) showed that the gender gap was closing on aptitude tests between 1960 and 1990, but boys fared better in mathematics and science and girls fared better in writing. The ETS assessment also showed that girls did well in natural science and not in chemical and physical sciences (Cole, 1997).

Hyde (1991) showed two areas of significant difference between women and men. The two areas were mathematical performance (d=0.43) and spatial perception (d=0.45). There was not a significant difference in verbal ability (d=0.24) (Blickenstaff, 2005; Hyde, 1991). Even though men did better in the study, the study showed a 2-to-1 difference in mathematics and science ability compared to other studies that showed a 20-to-1 difference (Hyde, 1996). Hyde suggested that the underrepresentation of women in STEM had other significant factors than just cognitive ability (Eccles & Wigfield, 1993; Eccles et al., 1993; Jacobs et al., 2002; Leaper et al., 2012). The IQ tests in the meta-analysis showed that the assessments only proved that a test was created to show no gender difference because there were equal questions that allowed males and females to succeed (Hyde, 1991). There was a moderate difference in mathematical ability, and the trend over time showed a "decline in the magnitude of gender difference" (Hyde, 1991, p. 19). Just because girls have similar cognitive abilities does not mean that marginalization and institutionalized stereotypes of women have been removed (Brickhouse, 2001; Zohar & Bronshtein, 2005).

Adolescent Girls

Leaper, Farkas and Brown (2011) suggested that personal and peer relations “may influence girls’ motivation” (Leaper et al., 2012, p. 268) in both mathematics and science. The social influences that girls receive from the environment and the personal influences they receive from home can shape a girl’s STEM perception (Grossman & Porche, 2014; Leaper et al., 2012). In their research, they looked at predictors that would indicate expectancy and value (motivation) in mathematics, science and English (Leaper et al., 2012). The participants were girls from Southern (71%) and Northern (20%) California and Georgia (9%) ranging from age 13 to 18 years with a mean age of 15.2 and a standard deviation of 1.4 years. All girls were given the survey, “What it means to be a girl” (Leaper et al., 2012, p. 272). The regression analysis for perceived support in mathematics and science was related positively for girls, as well as for English. When mothers and peers of the girls gave support, motivation was positively rated (Leaper et al., 2012). Other research supports the idea that children whose mothers who give support achieve higher in mathematics and are motivated in mathematics and science. On the other hand, mathematics and science motivation had the opposite effect when related to English. Peer support was negatively related; if girls’ support was in one domain it was less in the other domain (Leaper et al., 2012). Girls may tend to take on the motivation of their peers; if their peers are motivated in mathematics and science they too will be motivated in the same domain. Gender roles “were not significantly related to girls’ motivation in” mathematics and science (Leaper et al., 2012, p. 278). It was also noted that girls who were aware of feminism and gender stereotypes had a higher motivation in mathematics and science. Girls who had peer support and parent support in the domains of mathematics and science strengthened their motivation (Eccles & Wigfield, 1993; Eccles et al., 1993; Leaper et al., 2012).

Underrepresentation of Women

The number of women and men in all jobs in the United States is almost equal. However, there is a big difference in the number of women in STEM jobs compared to men. Also, women who are in STEM jobs earn more than women and men who are not in STEM jobs.

In 2009, 52% of men and 48% of women held all jobs in the United States compared to 76% of men and 24% of women holding STEM jobs. Women earned less than men in both non-STEM jobs and STEM jobs. Women earned 21% less than men in non-STEM jobs, and women earned 14% less than men in STEM jobs (Beede et al., 2011). The difference has not changed according to Noonan (2017); the ratio of 76% to 24% men to women in STEM jobs has remained the same even with women in STEM making 35% more than women in non-STEM since the first report in 2011 (Beede et al., 2011; Noonan, 2017).

This inconsistency in pay, when the promise was that STEM jobs would help women make more money, does not seem to encourage women into entering or staying STEM degree programs. Women are earning as many STEM degrees as men except in the area of engineering and physics. Gender stereotypes in the STEM fields and degree programs are a factor of why women are leaving or not staying in the STEM Pipeline (Beede et al., 2011; Cundiff et al., 2013; Noonan, 2017).

Women are more likely to earn degrees in physical and life science and are less likely to pursue engineering degrees. Degrees in mathematics and computer science are even lower. In 2009, of the 6.7 million workers that were male and had STEM degrees, 31% held life and physical science degrees, 48% held engineering degrees, 15% held computer science degrees and 6% held mathematics degrees (Beede et al., 2011; *Noonan, 2017*). Of the 2.5 million female STEM workers, 57% held degrees in life and physical science, 18% held engineering degrees, 14% held computer science degrees, and 10% held mathematics degrees (Beede et al., 2011; Brainard & Carlin, 1998).

In 2015 (Table 2.1) there were 7.9 million men and 3.4 million women in STEM degree fields. There were 31% men and 59% men who held physical and life science degrees, 46% men and 19% women with engineering degrees, 5% men and 14% women with a mathematic degree, and 17% men and 8% women who held a degree in computer science (Noonan, 2017). Table 2.1 shows the difference in men and women by educational attainment that are in STEM jobs.

This following table demonstrates that women, whether having a higher education degree or no degree, still are not entering STEM jobs at the same rate as men.

Table 2.1. Workers in STEM by Educational Attainment

Educational Attainment	Men	Women
No College	2%	1%
Some College	5%	2%
Associate Degree	10%	4%
Bachelor’s Degree	17%	5%
Master’s Degree	21%	7%
Doctorate	22%	11%
Professional Degree	4%	2%

Note. Noonan, 2017

Based on Beede et al. (2011) and Noonan (2017), little has changed in the underrepresentation of women in STEM jobs. Physical and life science are degree programs that women are more likely to attain compared to men in engineering. There is also a smaller wage gap in STEM careers between men and women. Women are opting out of the STEM pipeline are more likely to pursue heath care or education careers (Beede et al., 2011; Noonan, 2017).

The underrepresentation of women in science has been a topic of discussion even before the turn of the century. “No potential loss of talent should go unexamined” (Strenta et al., 1994, p. 2). By the 1970s and 1980s there still was a shortage in the amount of research that looked at the inequities of women in science. The research that was performed was that of a psychological nature and compared women to the dominate culture male (Baker, 2002; Blickenstaff, 2005; Greenwald et al., 1998).

Women need to be part of the decision making process, and without their voice women will not gain access to “economic and social power (Brainard & Carlin, 1998, p. 1). Girls leave their major in science at a much faster rate than males, not necessarily because they are female but sometimes because of low grades in the first two years of college or other factors. Strenta, Elliot, Adiar, Matier, and Scott (1994) examined high-ability students who scored well on aptitude tests and earned high grades in high school. STEM dropout rates were higher for women compared to men. Of the initial 5,320 students in the study, 35% women and 49% men were interested in science at the university level. Of the students who were interested in science, 40% left the science pipeline and went into other majors. Of those who continued to study science, only 48% women and 66% men stayed in the discipline. Strenta et al. (1994) hypothesized that women left science within the first two years of college due to differences in intellect or lack of preparation in science. Each science field of interest had varied grades by gender. Men had higher grades than women. Women who were interested in science had better grades than women who were not interested in science. The study also showed that women were less confident in their science ability compared to male peers even when grades were the same.

A longitudinal study of undergraduate women in engineering and science tracked five cohorts of 100 students in either their engineering or science program. Brainard and Carlin (1998) examined factors affecting the retention of female students in engineering and science, and factors that might increase retention rates. Brainard and Carlin (1998) stated that girls left science and engineering because of boredom with the curriculum, low confidence in their ability, low quality teaching, and a highly competitive atmosphere. Some of the reasons for attrition among female students were courses that were not interesting, coursework requiring lab work, poor high school preparation, instructors who were more interested in research and not helping students, and the courses seemed to be there to weed out students (Brainard & Carlin, 1998; Strenta et al., 1994). While this weeding out practice was true for male and female students, female students were affected more often than male students. If there are discriminatory factors at the university level this can be changed, however some, like poor preparation in secondary school, may be out of the scope of the university (Adair, 1991; Strenta et al., 1994).

Many women left science and engineering coursework because of feelings of incompetency, even though their academic work was producing high marks. In the cohort longitudinal study, women expressed losing confidence and not being accepted in their department area of study by their senior year. One helpful factor for women in science or engineering programs was having access to Women in Engineering (WIE); women who succeeded in the programs reported WIE as a significant contribution to their success (Brainard & Carlin, 1998).

There have been many researchers on the subject of why women are underrepresented in STEM Fields. Agee and Li (2018), Blickenstaff (2005), Chesler, Barabino, Bhatia, and Richards-Kortum (2010), and Goulden, Mason, and Frasch (2011) gave similar reasons for women leaving the STEM pipeline (Table 2.2).

Table 2.2. Reasons Women Leave STEM Careers

Number	Reasons
1	Work and family
2	Institutional biases
3	Poor attitudes in STEM
4	The absence of female scientist/engineers as role models
5	Irrelevant curricula
6	Poor support structures

Note. Adapted from (Agee and Li, (2018); Blickenstaff (2005); Chesler et al. (2010); Goulden et al. (2011)

According to Cunningham et al., (2015), with NAEP, women earn almost 50% of doctoral degrees in biology and fewer doctorates in physical science and engineering. In physical science, women earn about 25% of doctoral degrees, and in engineering women earn 15% of doctoral degrees (NAEP, 2008). Women comprise 30% of professors in biology, compared to 16% in physical science and 17% in engineering (NAEP,2008). “These biases can have an impact on decisions about admissions, hiring, and promotion. These biases may contribute to popular beliefs about same-sex education and learning styles, and dissuade some individuals from persisting in science” (Hyde & Linn, 2006, p. 600).

The self-efficacy of women is tied to their social and personal identity (Ellemers & Haslam, 2011). A woman’s social group is an influence on beliefs and is developed with personal beliefs about self and others. This means that society has a role influencing women’s beliefs about themselves. Since history tells us that STEM is a male-dominated field, both gender identities and social identities should be considered (Piatek-Jimenez et al., 2018). Because of gender and social identities, women’s self-efficacy may include both male and female attributes or the adoption of male attributes in order to cope within a male-dominated field (Ely, 1995).

Self-Efficacy in STEM

Self-efficacy allows an individual to have a belief in their own abilities to be successful with new challenges (Haslam & Ellemers, 2011). STEM self-efficacy is influenced by both social and gender beliefs (*Self-Efficacy Theory*, 2018). In elementary children, social and gender beliefs are directly related to their parents’ beliefs. If a child’s parent holds a position and a traditional gender role, the child will have similar beliefs, and children with parents who have non-traditional gender careers or roles are more likely to have higher self-efficacy in areas that are non-traditional (Piatek-Jimenez et al., 2018). This also holds true in the self-efficacy of girls in science and mathematics. If the mother holds a stereotypical position or non-paid role in the family, her daughter's self-efficacy is lower in science and mathematics, but if the opposite occurs, the daughter has higher self-efficacy in science and mathematics (Piatek-Jimenez et al., 2018). Similar to parents, teachers' gender beliefs and stereotypes influence students' self-efficacy (Gunderson et al., 2012). Gender self-efficacy starts at an early age and is influenced when students enter kindergarten (Gunderson et al., 2012).

This study investigates STEM content and cognitive and affective outcomes of STEM integrated curriculum at the elementary (K-5) level (Lamb et al., 2015). Lamb, Akmal and Petrie (2015) believed that integrating STEM learning in elementary helped "develop cognitive and affective aspects" (p. 431) in children's belief systems. In order to develop more future STEM participants in the global workforce, it is important to understand student attitudes toward STEM (Cooper & Heaverlo, 2013). In addition, teachers need to understand student self-beliefs related to STEM content to help develop instructional practices (Cooper & Heaverlo, 2013; Lamb et al., 2015).

Lamb et al. (2015) used a cognition-priming model to describe the STEM classroom. The cognition-priming model is activated when a student learns to reason while observing a scientific phenomenon (Lamb et al., 2015). STEM learning is dependent on both cognition-priming model and affect-priming model where students learn the concepts in STEM and are able to argue their position with problem-solving skills (Lamb et al., 2015; Osborne, 2010).

There were two learning models used in the study, the cognition-priming model and the affect-priming model (Lamb et al., 2015). Both learning models address the separation between content outcomes, cognition and affect in science literature (Lamb et al., 2015). Both learning models link attitudes in science, thinking in science and perception of science (Bohner & Dickel, 2011). Lamb et al. (2015) posed the following research questions:

- What is the effect of an integrated STEM curriculum on student affect, specifically Self-Efficacy and Interest related to science and technology?
- Does exposure to a STEM integrated curriculum generate change related to student cognition related to Mental Rotation and Spatial Visualization?
- What is the relationship between affect, cognition, and science content score outcomes?

Cognition priming occurs when an external stimulus is given to a group of participants that triggers the group to examine the stimulus by using cognitive constructs before affective constructions (Lamb et al., 2015). Affective priming elicits a response such as irritation, anger or removal of cognition/disengagement (Lamb et al., 2015). The effects of repeated failure will give students a negative interest and associative affect (Lamb et al., 2015).

Student beliefs are beneficial in understanding their perspectives in STEM. Self-reporting measures cognitive, social and behavioral skills with the four components of verbal messages, social encouragement, mastery experiences, and peer success. Any individual that perseveres through a problem gains self-efficacy in that area (Lamb et al., 2015; Wang, 2013). Modes of influence help formulate and change behavior in order to complete an activity or task (Bandura, 1993). Low self-efficacy towards STEM brings apathy and decreased likelihood of persevering through a task (Zimmerman, 1989).

Elementary students have a high level of self-efficacy in STEM. Students who have access to task mastery and high cognitive learning are able to carry this learning into their higher level education and career (Bandura, 1993; Wang, 2013) Increasing a person's self-efficacy in an area influences career intentions (Lamb et al., 2015; Silvia, 2003).

Lamb et al. (2015) studied students in kindergarten, second and fifth grades in the Mid-Atlantic area of the United States (n=254). The intervention group consisted of 111 students and that comparison group consisted of 143 students. The study used a quantitative triangulation study using an ANOVA and structural equation modeling. The intervention consisted of $n=37$ kindergarten, $n=44$ second graders, $n=30$ fifth graders. The kindergartners had one year of the STEM curriculum, second graders had two years of the intervention, and fifth grades had three years of the STEM intervention. The intervention consisted of three hours per week of STEM intervention over the school year with a total of 90 hours of STEM curriculum. There was a pre and post assessment.

The data collection was a psychometric analysis (Lamb et al., 2015). The Science Efficacy in Technology and Science (SETS-SF) was used for the assessment along with the 18-item Science Interest Survey (SIS-E). Both assessments used Likert scales and the Rasch model equation $M_{Infit} = 1.00$, $M_{Outfit} = 1.01$, $M_{Dif} = .02$, with a Rasch Reliability = 0.84. The paper-folder test (PFT) is a cognitive assessment by Ekstrom (Ekstrom et al., 1976; Lamb et al., 2015).

Lamb et al. (2015) found higher self-efficacy scores for the treatment group vs. the comparison group at all three grade levels. While both the treatment and control groups showed a decline in science interest, the treatment group only dropped 1 point on a 20-point scale, from 20 to 19. The comparison group dropped 3 points on the same scale, from 15 to 12.

The development of “cognitive, content affective relationships and outcomes associated with STEM based education” (Lamb et al., 2015, p. 428) was greater when STEM curriculum was introduced to students. The findings showed significant differences in cognition in STEM areas starting in second grade, and changes in cognition from second to fifth grades (Lamb et al., 2015). Schools that provided STEM “develop higher levels of self-efficacy and interest” (Lamb et al., 2015, p. 429). As students moved from primary to middle school, if their level of knowledge in STEM was lower or students had a negative feeling about STEM, their self-efficacy in STEM fell compared to students who had access to STEM in elementary (Lamb et al., 2015; Plass et al., 2013).

As they mature, students without access to STEM-related curriculum are less likely to pursue STEM based classes or careers which contributes to the STEM pipeline (Blickenstaff, 2005; Kekelis et al., 2005; Lyon et al., 2012). There is greater opportunity for students to develop cognitive and efficacy attributes toward STEM tasks when exposed to STEM at ages as early as infancy (Tai et al., 2006). When younger students experience STEM external antecedent stimuli, there is a connection between how they learn and develop their science skills.

A path analysis was conducted with science self-efficacy, science content, science interest, spatial visualization and mental rotation. The path analysis supported inclusion of STEM content and context as part of students' academic development at an early age (Lamb et al., 2015). The ANOVA results showed that students developed their affect over time between second and fifth grade. Affect develops earlier than cognition and can develop as early as 2 years of age (Monk et al., 2013). The earlier there is exposure to STEM, the more likely the perception of STEM will increase (Lamb et al., 2015; Osborne, 2010).

Stereotypes

Stereotypes can stigmatize and influence a group of people and stop the group or individual from pursuing an area of interest. Stereotypes cause discrimination and can impede academic and personal growth within an organization or school environment (Stangor et al., 1998).

Stereotypes can be triggered by situational cues causing anxiety even when individuals have the ability to succeed in relevant domains. Social identity threats can lower that academic performance of another group (Stangor et al., 1998). A few social groups and identity examples are race, gender, political and religious affiliations and economic status; situational cues will change when different environments are prevalent (Murphy et al., 2007, p. 879). Individuals will take on the specific identity in a setting where they feel most vulnerable (Branscombe et al., 1999; Brewer & Brown, 1998). A decreased sense of belonging occurs when objective and subjective experiences of identity lower the participation of an individual in an academic setting (Murphy et al., 2007, p. 880).

Women are underrepresented in mathematics, science and engineering (MSE) work environments. Women are subjected to situational cues that decrease their ability of success based on gender situational stereotypes. It has also been found that parents' choice of careers and gender roles play an important part in how girls choose careers (Jacobs et al., 2006). Parents who have careers in specific fields are more likely to encourage their child to choose a field that is of interest to their parents (Lupart et al., 2004). Parents also have a strong influence on gender stereotypes both positive and negative (Jacobs et al., 2006).

The value that a child places on a domain affects their ability to perform well in that domain (Harter, 1992; Jacobs et al., 2002).   Children who feel like they are competent in a domain increases how they will value the area of interest (Eccles & Wigfield, 1993; Jacobs et al., 2002). When a child can find meaning in an area, both performance and interest increases (Bandura, 1993; Harter, 1992; Jacobs et al., 2002; Silvia, 2003; Wigfield & Harold, 1997).

Jacobs, Lanza, Osgood, Eccles and Wigfield (2002) looked at *Changes in Children's Self-Competence and Values: Gender and Domain Differences across Grades One through Twelve*. This was part of another longitudinal study that looked at students' perceptions, values and domain choices (Eccles et al., 1993). The participants included students, their parents and teachers from a middle class, Eurocentric school district in the Midwest. There were three cohorts, male and female, of approximately 250 students in each cohort over a 6-year period. The study used a cross-sequential model where students were studied in grades 1, 2 and 4 and by the 6th year of the study students were in their freshmen, sophomore or senior year of high school (Eccles et al., 1993).   Each student completed a survey at the end of each school year. The younger children had their questions read to them, and older children read the questions themselves during a 20-minute time frame.

The data gathered looked at the following domains: mathematics ability and value, reading ability and value, sports ability and value and social ability (Eccles et al., 1993). The analysis looked at the three areas using a Hierarchical

Linear Model (HLM). HLM gave data that were linear and nonlinear with relation to gender differences. Eccles et al. (1993) used regression analysis to look at the changes in ability and value over time and the relation to gender. “The most striking finding across all domains was that self-perceptions of competence and subjective task values declined as children got older” (Jacobs et al., 2002, p. 14).

The study found that self-perceptions either declined or were maintained within the cohorts for both male and female (Jacobs et al., 2002). It was noted that the demographics of the study were Eurocentric and middle class, and the same findings may not apply to different demographics. Also, students may have entered the study with different levels of value and perceptions from their own home experience and societal norms in the research domains. The authors suggested that the study be completed with a more diverse population and expanded to more domains (Jacobs et al., 2002).

Using first year data from the study by Jacobs et al. (2002), Eccles et al. (1993) explored the development of students’ self-perceptions and task perception for grades 1, 2 and 4. Eccles et al. (1993) conducted two analyses using across-domain exploratory factor analyses; one viewed the students’ beliefs separately in the domains, and the other examined whether beliefs actually formed factors distinctly. The outcome of the study showed “that children’s activity-related self- and task perceptions are differentiated” as early as first grade (Eccles et al., 1993, p. 8). Other studies stated that children as young as kindergarten have different perceptions in separate domains (Harter, 1992;

Marsh, 1989, 1993). This is important because children's self-concept, self-perception and self-efficacy develop at a young age and are differentiated for both boys and girls by first grade (Eccles et al., 1993; Marsh, 1989, 1993). Girls' self-perception of mathematics starts early and because of this, girls, as early as kindergarten need to have equitable access to academics that help increase their perceptions.

Career Self-efficacy

Girls start to leave the STEM pipeline around middle school. A girl's belief about herself, starting at age 10, is highly influenced by her environment. Social role theory and social cognitive career theory (SCCT) provide insights on how the environment affects a girl's self-efficacy (Shapiro et al., 2015). Girls' STEM career interests are dependent upon their perceptions, which are influenced by their environment (Yager & Penick, 1986). This environment includes parents, school curriculum and teachers, and peers (Bamberger, 2014; Eccles, et al., 1993; Piatek-Jimenez et al., 2018).

Social role theory relates to a person's own culture and the role of gender in that culture. SCCT looks at environmental and personal factors contributing to how the individual interprets the world. Children develop gender role perceptions at around the age of two, and middle school age is when career identity is prevalent (Macht-Jantzer et al., 2009). Children are affected by the media as a strong influencer of gender roles (Marlino & Wilson, 2003). When children watch television, only 19% of women are in a career role and 27% of women are shown doing house work, compared to 1% of men doing house work (Hartung et al., 2005). Men are more likely to be shown in a job role compared to women (Hartung et al., 2005). Books published from 1900 to 2000 showed male characters 57% of the time and women at 31% of the time, and in Caldecott awarded books, male leading characters outnumbered females 3 to 1 (McCabe et al., 2011; Narahara, 1998).

By the time girls are at the end of their K-12 academic career, they beat out boys in terms of GPA and college enrollment. In their fourth year of high school, girls' average GPA is 3.48 compared to boys' GPA of 3.28. Girls enroll in college at a rate of 1.4 girls for every 1 boy. Girls perform well academically, but somehow underperform or "lose ground" professionally (Shapiro et al., 2015, p. 1). The following study used the Social Cognitive Career Theory (SCCT). The goal was to try and answer key questions about middle school girls and their self-efficacy and career interests:

> " 1) Do boys and girls (personal input) have different career interest, aspirations, and goals, and do these differences reflect gender social roles?"; 2) "What messages (background input) have they heard about careers as they interact with gendered landscape around them?" 3) "Has girls' participation in Girl Scouting had any impact on their self-confidence and their career aspirations? The purpose of this study is to "determine whether limiting factors in relation to career opportunities, expectations, and self-beliefs might emerge as early as 10 to 12 years of age."

(Shapiro et al., 2015, p. 6)

Furthermore, the purpose of the study by Shapiro et al. (2015) was to "determine whether limiting factors in relation to career opportunities, expectations, and self-beliefs might emerge as early as 10 to 12 years of age" (p. 4). The study also looked at how teachers and curriculum could mitigate the above factors (Shapiro et al., 2015). The setting for the study was an online survey of at least 1,200 middle school boys, Girl Scout Girls (GSG) and non-Girl Scout Girls (NGSG). The survey focused on career goals, self-efficacy, career aspirations among both genders, and Girl Scouts members. The survey took place in New England, New York and Pennsylvania. The sample of individuals included 414 boys, 775 girls of which 475 were identified as Girl Scouts and 299 non-Girl Scouts. The average age was 12.2 years with a range of 10 to 15 years of age. The race demographics were 82% Caucasian, 5% African-American, 4% Asian and the rest other.

The findings showed that boys and girls believed that boys had more career opportunities available to them. Eight times as many females compared to males stated they would stay home with children. A list of what careers girls and boys were interested in, came from the *Teen Girls'* Study (Marlino & Wilson, 2003). Each child was asked what their career choices would be based on a list of 20 professions from the Teen Girls' study. Each child was then asked to imagine they were the opposite sex, what they believed their choices would be. The average of the top five choices was shown in a chart (Shapiro et al., 2015).

The top choice for boys was a job in STEM. When boys imagined themselves as girls, the top choice was job in arts (performance, writing, designer or artist). The top choice for girls was the arts, and when girls imagined themselves as boys the choice of a career was athletics. However, girls' second choice, when imagining themselves as boys, was a career in STEM (Shapiro et al., 2015).

Three clusters of confidence were analyzed; 1) leader in charge, 2) responsible leader, and 3) team building. Boys scored lowest on average across all three clusters; NGSG scored second lowest, and GSG scored highest. GSG were less likely to believe that boys had more career opportunities, and GSG stated that if they stayed home with children it would be temporary instead of permanent. Also, girls who participated in Girl Scouts were more likely to embrace STEM careers as options; 13.5% GSG would choose STEM careers compared to NGSG at 10.7% (Shapiro et al., 2015). GSG showed interest in male dominated fields in business along with their high confidence and greater interest in medical, professional and arts fields requiring higher education.

The findings by Shapiro et al. (2015) show that girls are thinking about their careers, and learning experience helped change perceptions of careers. There is concern for future employment for girls; 40% of mothers are the primary income provider in a household. Middle school girls are more likely to be interested in "female-dominated industries;" their low interest in STEM careers affects "their future earning potential" (Shapiro et al., 2015, p. 10).

We are also moving from blue collar jobs to service and knowledge-based jobs (Shapiro and Sax, 2011). Boys tend to make more money in male-dominated jobs compared to females in the same job. Girls' lack of interest in STEM careers takes them out of a higher income bracket. Careers in STEM tend to be more resistant to economic hardship. The STEM pay gap is lower than in non-STEM fields; STEM career options grew 17% by 2018 compared to non-STEM careers (Beede et al., 2011).

Middle school students in the study (40% girls, 33% boys) turned to their school for guidance following with family, internet, TV and magazines for their primary source of career information. Based on the impact middle school professionals have on students, Shapiro et al. (2015) offered a three-prong strategy for educators working with middle school students: "add specificity to messaging from parents; increase STEM participation; and link relational thinking to interest in careers" (Shapiro et al., 2015, p. 10).

The message to students and parents must be explicit and implicit regarding career options. Not just the typical, "do whatever makes you happy" (Shapiro et al., 2015, p. 8). Exposure to careers is a must; for example, exposure should include job shadowing, field trips, guest speakers, and other ways of connecting to careers aspirations. Without exposure students may not have access later (Kekelis et al., 2005).

Questions at the end of Shapiro et al. (2015) were: 1) Based on the leaky pipeline, what can middle school professionals do to keep girls in the pipeline toward leadership and in careers that will meet their future financial needs? 2) What can teachers and counselors do to counter the gendered messages that narrow middle school girls' career choices?"

The major conclusion from Shapiro et al. (2015) was that middle school leaders and teachers needed to be aware of girls' career interests. However, the authors recommended caution because the sample size consisted of 82% Caucasian students, and the setting was in the Northeastern part of the United States. The goal is to give educators the ability to think about how to keep girls in the pipeline and to provide corroboration to support the educational system.

Girls tend to be strong in reading and writing at young ages. The assumption is that girls are more likely to find pleasure in reading; "literature allows them to relate to fictional characters and to understand how their lives are experiences. Girls, like women, often cite strong preferences for reading fiction" (Ford et al., 2006, p. 272). Furthermore, girls tend not to create scientific ideas as they do with fictional characters. This is primarily due to scientists being stereotypically masculine. The views of girls may be that science books are for boys and fictional books are for girls (Dutro, 2001).

By the time children enter second grade they have already learned gender bias according to Dutro (2001). Girls and boys are asked to line up into separate lines as a way to organize students; this creates an invisible bias border that girls and boys believe is uncrossable (Sadker & Sadker, 2010). Boys and girls learn gender differences at a young age. Depending on their home life, this could range from washing the dishes or cleaning up the yard. When fifth grade boys where asked if they liked a particular book, their choice may have been influenced by another boy, by their masculinity or hierarchy in the class. Boys in this study were open about showing their masculinity and how displeased they were with books that were considered for girls (Dutro, 2001). Girls chose books that were deemed more likely to be a “boys” book with pride showing their self-worth. Even when boys chose books that were considered “girls” books they were “shielded from ridicule” (Dutro, 2001, p. 379) because of their social status in the class.

Most reading for girls and boys in elementary schools is fiction. When boys choose informational books, it is because it is the norm at home and at school (Dutro, 2001; Finders, 1997; Sadker & Sadker, 2010). Girls’ literature is mostly fictional. “The omission of written texts in science instruction may be particularly detrimental to girls” (Ford et al., 2006, p. 2). Girls tend to be strong readers, usually performing better than boys in this area (Ford et al., 2006). The identity of girls is chosen at a young age, and what they are exposed to can formulate this identity (Ford et al., 2006).

In the study, *Elementary Girls’ Science Reading at Home and School*, the participants were third graders (Ford et al., 2006). There were 45 third graders from six different classrooms and their family members. Of the classrooms the demographics are 64% White, 24% African American, 8% Asian/Asian American, 2% Latina, and 2% multiethnic. The students were interviewed individually about the books they liked or disliked over a 50-minute period. Family members were interviewed for 40 minutes, and teachers were interviewed between 45 minutes and 120 minutes with a wide range of science literacy choices (Ford et al., 2006). The teachers in this study were part of a National Science Foundation (NSF) project in literacy and were more likely to have science literature in the classroom (Ford et al., 2006).

The findings of Ford et al. (2006) suggested differentiation and choice for girls and the way they choose to learn. Many of the girls reported that they received their books from the classroom bins, and some of them reported that if they had books at home, the books came from either the library or local book store. The books read in class were mostly of life science and hands-on activity books. If there were other science areas taught in class, it was less likely that a science book would be accessible. Also, the local book stores had more life science books compared to other sciences, whereas the library had a better mix of informational science books (Ford et al., 2006).

Animal books were chosen 88% of the time by girls. They also liked books that became movies or were part of a series. Most of the girls did not name titles, and only 46% of girls mentioned science books as a choice. Parents reported a lower percentage of whether or not their daughters enjoyed animal books or science books (Table 2.3).

Table 2.3. Girls' Interest in Fiction, Science, and Animal Books

Genre	Girls' Reported Interest (percentage of Girls indicating interest)	Parents' Report of Their Daughters' Interests (Percentage of Girls)
Fiction	100	100
Animal	86	27
Science	46	21

Note. Data from the subset of girls whose families were also interviewed (n=29).(Ford et al., 2006)

Based on the study, girls need to have access to science texts; most importantly narrative style science books (Ford et al., 2006). In addition, the study showed that the girls' idea of science was mostly tied to school. The researchers started a study group where girls had access to science books outside of school and with a group of peers that had the same interests. Also, book clubs for mothers and daughters were started to pique interest in science and to help families learn the importance of science together (Ford et al., 2006).

Inequities in science education can start as early as third grade and suggest that science interventions should begin earlier than third grade (Kohlhaas et al., 2010). Students who have real world science experience at younger ages are more likely to pursue degrees and careers in science or engineering (Tai et al., 2006). This is based on survey and data analysis of eighth graders completed by the National Education Longitudinal Study (Kaufman & Bradbury, 1992; Kaufman & Rasinski, 1991).

Girls who have access to collaborative and problem-solving learning environments are more likely to show STEM interests. All-girl grouping can be just as effective as heterogeneous grouping (Baker, 2013). Girls who are given positive feedback and the ability to complete a science task successfully are able to increase their self-efficacy in science (Baker, 2013; Salmon et al., 2015).

According to Kerr and Robinson Kurpius (2005), girls who gained access to career intervention were more likely to choose nontraditional careers. Women who identified with a particular domain or profession would succeed in their career choice (Kerr & Robinson Kurpius, 2005). "The young woman who sees herself as a mathematician, an engineer, or a scientist is more likely to stay with her chosen field than one who sees herself simply as a college student" (Kerr & Robinson Kurpius, 2005, p. 87). Other factors included playing a leadership role in college, particularly in activist groups on campus, and having a mentor in their occupational choice (Kerr & Robinson Kurpius, 2005). The leadership roles helped college women to advocate for themselves and for others; the mentors helped remind the women of their goals and dreams (Kaufmann, 1981; Kerr & Robinson Kurpius, 2005). Kerr and Robinson Kurpius (2005) wanted to understand "career behaviors, self-beliefs and at-risk behaviors of teenage girls" by evaluating the impact of the Talented At-Risk Girls: Encouragement and Training for Sophomores project (TARGETS) (Kerr & Robinson Kurpius, 2005, p. 90).

The TARGETS program (1994) was first funded by the NSF. TARGETS was a “values-based career intervention” for girls that were at risk in their perceptions of both science and mathematics (Kerr & Robinson Kurpius, 2005, p. 89). There were 502 girls who received the intervention program over 7 years with an age range of 11 to 20 years and were given a pre-test. The intervention took place in Arizona with 45 schools in suburban, rural, urban and reservation communities (Kerr & Robinson Kurpius, 2005). The TARGETS program was a whole day (TARGETS day) where the girls were given a values inventory, self-efficacy assessment, guided exercise of girls’ imagery of a work day in the future, career interest inventory, and a group discussion on barriers in STEM (Kerr & Robinson Kurpius, 2005). The first 2 years, 131 girls were given a post-assessment after TARGETS Day. The remaining 5 years, there was a pre-assessment before the day began and a post assessment between 3 and 4 months after the TARGETS day. NSF provided additional funding in 1997 to give training for teachers, school leaders, and college professors about TARGETS.

The instruments used in the study were the Rosenberg Self-Esteem Scale (SES) to measure self-worth, a 10-item survey with a 4-point Likert Scale from strongly agree to strongly disagree, the Career Behaviours Inventory (CBI), with a score from zero to 11, the Educational Self-Efficacy-Adolescence (ESEA) assessment, a 7-point Likert scale that measures self-efficacy, and the Adolescent At-Risk Behaviors Inventory (AARBI) that assessed at-risk behaviors such as, but not limited to, cigarette use, gang involvement, drug use, driving/safety and exercise (Kerr & Robinson Kurpius, 2005). Girls were asked demographic information such as age, grade, ethnicity, information about their preferred school activities, parents education level, completed math and science classes, career goals and perceived obstacles (Kerr & Robinson Kurpius, 2005).

Table 2.4. Cronbach's Alpha by Assessment

Assessment	Cronbach's Alpha
Rosenberg SES	Pre-test .84 Post-test .84
CBI job self-efficacy	Pre-test .96
CBI school self-efficacy	Pre-test .93
CBI math/science school self-efficacy	Pre-test .85
CBI future self-efficacy	Pre-test .77
AARBI	Range from .68 to .85

The TARGETS program girls were middle to high school age. The chi-square compared traditional and nontraditional career desires. The chi-square was significant $p <. 001$; where a higher number of girls chose traditional careers or nontraditional careers with 13 girls switching traditional careers to nontraditional careers (STEM). An ANOVA showed that girls increased their search in careers. However, TARGETS seemed to only impact the career goals of the girls and not changing from traditional careers to nontraditional careers. The findings showed that TARGETS impacted girls' career aspirations. The findings did not necessary impact self-efficacy in science and mathematics but did impact the self-beliefs in themselves (Kerr & Robinson Kurpius, 2005).

Learning environments that offer this are project-based learning (PBL), project-based science and anchored instruction (Cooper & Heaverlo, 2013). The three methods call for the students to use their own problem-solving skills, background knowledge from multidisciplinary subjects, and their ability to collaborate with others in a group environment to come up with a solution. "The problem and potential solutions are the motivators for student learning" (Cooper & Heaverlo, 2013, p. 2) and shed light on how students become active in their own learning.

Project Lead the Way

Richard Blais believed that the only way students would be prepared for STEM careers was to give them access to hands-on science material in middle and high school (Nagy, 2017). Blais started in 1996 with a group of high school educators in Clifton Park, New York, designing what is now the PLTW curriculum for engineering. Soon after its publication, more than 12 schools in New York started using the science curriculum. Blais' first higher education affiliation to partner with the team was Rochester Institute of Technology. The staff worked together based on educational need in technology and engineering.

Soon after Blais developed PLTW engineering curriculum, Richard Liebich, CEO of Syso Foods Charitable Venture Foundation (CVF) partnered with PLTW. Richard Liebich got ongoing funding for PLTW and helped PLTW to become a not-for-profit organization in 1997. After the engineering curriculum, Biomedical Sciences Program was introduced in 2007, and middle school curriculum followed quickly after with its energy curriculum in 2010.

In 2014 the PLTW K-5 Launch Curriculum was made available to all schools. To receive the curriculum there needed to be at least one lead teacher to train the entire school site. The lead teacher attended a three-day intensive training at a local university with other lead teachers who already used and taught PLTW Launch curriculum in their classroom.

PLTW Launch Curriculum is separated into four modules per grade level and is aligned to NGSS with CCSS mathematics and ELA recommendations. The modules are listed by grade level (PLTW, 2018) in Table 2.5.

Table 2.5. Project Lead The Way Launch Curriculum – K-5

Grade Level	Modules
Kindergarten	Structure and Function: Exploring Design, Pushes and Pulls, Structure and Function: Human Body and Animals and Algorithms
First Grade	Light and Sound, Light: Observing the Sun, Moon and Stars, Animal Adaptations, Animated Storytelling
Second Grade	Materials Science: Properties of Matter, Material Science: Form and Function, The Changing Earth and Grids and Games
Third Grade	Stability and Motion: Science of Flight, Stability and Motion: Forces and Interactions, Variation of Traits and Programming Patterns
Fourth Grade	Energy: Collisions, Energy: Conversions, Input/Output: Computer Systems and Input/Output: Human Brain
Fifth Grade	Robotics and Automation, Robotics and Automation: Challenge, Infection: Detection, and Infection: Modeling and Simulation

Note: (PLTW, 2018)

Each grade level uses the online collections program through the PLTW course library. The program recommends that all K-5 levels revisit the training at the beginning of each school year. Teachers have the ability to view their grade level modules and the modules of other grade levels. Each model has a student view and teacher guide. From kindergarten through fifth grade the students are given a story or scenario from the perspective of children. These children are Milo, Susie and Angelina. The three students also grow up with the children as they go through their grade levels.

The teacher guide gives an outline of the NGSS framework, activity explanation and a check for understanding. The modules are built using the Activity Problem Based Learning (APBL) model. Students collaborate with their peers to determine the solution to Milo, Susie and Angelina's problem. Two of the characters are female and one character is male. The characters show that females taking part in APBL, just as NGSS recommended in their case study (*NGSS California*, 2013; PLTW, 2017). Each module has at least two activities, a project and a problem. Students either use the engineering design process or the scientific method to determine their solution.

Students who have a high quality science education will have access to what scientists careers entail, use the language of the discipline, practice using hands-on activities and involve real world and big idea experiences (Dorph et al., 2011; Innovate, 2014; PLTW, 2017).

Summary

It is imperative to include STEM in elementary schools (Lamb et al., 2015). More importantly, it is necessary for girls to have access at a young age as this is where their perceptions and self-efficacy are malleable (Baker, 2013; Tai et al., 2006). Girls' perceptions in STEM are much lower by the time they reach middle and high school. Giving girls explicit access to STEM in elementary school can increase their self-efficacy and perception, and they are more likely to keep this through their K-12 academic careers. Students who have access to problem-solving educational environments develop critical thinking, creativity and collaborative skills. These are essential in a 21st Century Learning Environment (Innovate, 2014). Giving girls head start initiatives in STEM at the elementary level will help increase the number of girls entering STEM while simultaneously addressing the leaky pipeline that is prevalent as adults. The under-representation of women in STEM is complex. With time, educators who understand why women leave the pipeline will help change the participation rate (Blickenstaff, 2005; Brickhouse, 2001; Brickhouse & Potter, 2002). Policy makers have described and discussed that STEM integration stimulates the self-efficacy of elementary children (Innovate, 2014). The Department of Education under the Obama Administration stated that the US workforce needed to increase the amount of role models for girls in STEM education (Tannenbaum, 2016). Teachers and curriculum should advocate for girls to increase their self-efficacy in science and engineering (Kerr & Robinson Kurpius, 2005).

In Chapter Three, the researcher will describe the methodology for the research. This research study was developed to fill the gap in the literature by exploring the perceptions of girls who have been exposed to PLTW Launch curriculum in their elementary career.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Chapter three outlines details of the research questions, hypotheses, methodology and design that includes the setting, demographics of the participants, data collection procedures, instrumentation, validity and the researcher's positionality.

The purpose of this study was to examine the perception of students engaged in STEM education and career interests of elementary school age girls. The four major components of self-efficacy and perception are selection, motivational, cognitive, and affective processes (Bandura, 1993). The belief in one's own ability is what shapes one's attitudes and perception in any given subject matter or domain (Bandura et al., 2001). In turn, "self-influences affect the selection and construction of environments" (Bandura, 1993, p. 2) and is directly related to an individual's process in motivation, aspirations, and success. Self-efficacy contributes to children's success in academics and the way they relate toward a subject domain (Bandura, 1993). When children are able to take ownership of their own learning in a specific domain with optimism, they are able to increase their own perceptions (Bandura, 1993). Students who have an interest in a field of study are more likely to take advanced course in high school and college. Also, individuals who have high interest in and perceptions of STEM subject areas are more likely to identify as individuals who will pursue a career in STEM (Lamb et al., 2012). By the time girls enter grade 4 or 5, their STEM identity either is or is not developed (Ford et al., 2006; Lamb et al., 2015; Macht-Jantzer et al., 2009). The way a student feels about STEM affects whether they have a higher perception in STEM and are more likely to have an interest in STEM careers (Bandura et al., 2001; Ford et al., 2006; Lamb et al., 2015).

The STEM school in the study employed Project Lead the Way (PLTW) Launch Curriculum for K-5 students, and the non-STEM school was an arts magnet school with a focus on music and visual and performing arts. In this chapter the research questions, design, setting, methodology, data analysis and validity is presented.

Research Questions

1. **Research Question 1:** What is the correlation between STEM perceptions and STEM career interests for the STEM (r_S) and non-STEM (r_{NS}) school girls'? More specifically, are the correlations between STEM perceptions and STEM career interests for the two groups equal?

   H_{01}: $\rho_S = \rho_{NS}$

   This null hypothesis states that there is no difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

H_{11}: $\rho_S \neq \rho_{NS}$.

The alternative hypothesis states that there is a difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

2. **Research Question 2:** What is the difference in means between STEM perceptions of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls who had no exposure to the STEM PLTW Launch Curriculum?

   H_{02}: $\mu_S - \mu_{NS} = 0$

   There is no difference in the population means in STEM perception for STEM and non-STEM students for the two groups.

   H_{12}: $\mu_S - \mu_{NS} \neq 0$.

   There is a difference in the population means in STEM perception for STEM and non-STEM students.

3. **Research Question 3**: What is the difference in means between STEM career interests of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that had no exposure to the STEM, PLTW Launch curriculum?

   H_{03}: $\mu_S - \mu_{NS} = 0$

   There is no difference in the population means in STEM careers for STEM and non-STEM students.

H_{13}: $\mu_S - \mu_{NS.} \neq 0$

There is a difference in the population means in STEM careers for STEM and non-STEM students.

Project Lead the Way

Project Lead the Way (PLTW) is an Activity, Project, Problem-based learning Approach that starts with at least three activities, a project, and a problem for students to solve. PLTW was designed to give all students access to STEM and prepare students for college and careers in STEM (*AP + PLTW*, 2019). PLTW activities are well-defined, and the project and problem are open-ended. Activities focus on knowledge and skill acquisition, the project focuses on meaning-making through investigation, and the problem is where students transfer their learning to real world STEM issues (*AP + PLTW*, 2019).

PLTW was designed to fully align to the Next Generation Science Standards (NGSS). PLTW covers physical science, life science, earth and space sciences and engineering, technology and applications of science through NGSS performance expectations (PE). The CCSS in both ELA and mathematics are integrated into each module (PLTW, 2019).

The PLTW Launch Curriculum was developed to be included in all elementary classes where teachers integrate STEM into their weekly or daily lessons. There are at least four modules in each grade level in elementary school. Lead teachers at a school site attend Core Training and then lead their own school site teachers through a two-day rigorous training at the beginning of each school year. The Core Training is provided by a current master teacher PLTW Launch trainers (*PLTW PD*, 2019).

Research Setting

Both schools in this study serve students in kindergarten through grade 5. All students in the district had the same application process to gain admission to the alternative school settings. They were admitted on a first-come-first-served basis, and on their attendance and behavior.

During the 2018-2019 school year, the non-STEM school, an arts magnet school, had an enrollment of 728 students from grades kindergarten through grade 8 and the STEM school's enrollment for the 2018-2019 school year is 569 students with grades starting in transitional kindergarten (TK) through grade 5. Both school sites had three fourth-grade classrooms and three fifth-grade classrooms. The non-STEM school and STEM schools received Local Control Funding Formula (LCFF) funds for specific focus areas; the non-STEM school received LCFF funds for their arts program and the STEM school received funds for the STEM focus, PLTW's Launch Curriculum.

Both schools in the district were eligible for free and reduced priced meals (FRPM). During the 2018-2019 school year all students in the district received free and reduced lunch based on the district's FRPM percentage. However, the non-STEM school’s eligibility rate was 78.6% and the STEM school’s eligibility rate was 71.7%.

Special education services were available to any student who qualified. The school district and both schools had a population of students who received special education services. The school district had just over 14% of students that receive special education services. The categories with a significant student population were intellectual disability, speech or language impairment, other health impairment, specific learning disability (SLD) and autism. Dataquest or the California Dashboard did not report the percentage of students with disabilities at the school level in the research district because the population of students was too small (Dataquest, 2019).

The non-STEM school had a resource specialist program (RSP) and a speech and language impairment program. The STEM school had programs that included, but were not limited to, speech and language impairment, RSP, mild, moderate, and severe profound handicap (SPH) programs. The school district along with the county office of education offered additional special education programs that included programs for the emotional disturbed, home-hospital bound students, and autistic students.

The demographics for the school district were not similar across schools. For example (see Table 3.1), the district’s African American/Black (AA) population was 20%, the non-STEM school was 8% AA and the STEM school was 13% AA; the Hispanic/Latin(x) population for the district was 68%, 81% for the non-STEM school and 69% for the STEM school. Table 3.1 provides a percent comparison of the district, non-STEM school and STEM school demographics by race.

Table 3.1. Demographic (race) Data Comparison of District and School Population

	District	Non-STEM School	STEM- PLTW School
African American/Black	20%	8%	13%
Asian	1%	1%	1%
Filipino	1%	0.3%	3%
Hispanic or Latin(x)	68%	81%	69%
Pacific Islander	1%	1%	1%
White	8%	5%	8%
Two or More Races	3%	2%	3%
Not reported	2%	2%	2%

Note. (Dataquest, 2019)

The school district served a high population of English language learners. Table 3.2 provides the percentages of students according to their language proficiencies. In particular, the table provides a break down for the following proficiency classifications: English Only (EO), Initial Fluent English Proficient (IFEP), English Learner (EL) and the Reclassified Fluent English Proficient (RFEP) students. The STEM school had a much higher population of EO students and the Non-STEM school had a slightly higher population of EL students (Table 3.2).

Table 3.2. Enrollment by English Language Acquisition Status

	District	Non-STEM School	STEM- PLTW School
English Only (EO)	71%	48%	80%
IFEP	2%	3%	1%
EL	15%	23%	14%
RFEP	12%	25%	5%

Note. (Dataquest, 2019)

California's state testing system is called the California Assessment of Student Performance and Progress (CAASPP) and uses the tests developed in partnership with the Smarter Balanced Assessment Consortium (SBAC). The assessment results provide data about students' success at meeting California State Standards in ELA and mathematics. The SBAC was accessible for students with disabilities and English language learners (ELL) because appropriate modifications and accommodations were made for the students with special needs. The flowing are the overall data for ELA, Mathematics and science assessment for the state, local county, district, non-STEM and STEM schools.

Table 3.3 gives the percentage of students who met and/or exceeded in ELA. Table 3.3 presents comparable data for the 2017-2018 school year in ELA in grades 3, 4 and 5 for the state of California, the research district's county, school district, the non-STEM school, and STEM school. Table 3.4 gives a comparison of data in mathematics for grades 3, 4 and 5 for the 2017-2018 CAASPP results.

Table 3.3. 2018-2019 English Language Arts-Smarter Balanced Assessment Consortium Achievement Percentage of Students that Exceeded and Met

	State	County	District	Non-STEM	STEM
Grade 3 (All)	49%	42%	26%	62%	39%
Grade 3 (female only)	52%	46%	28%	56%	40%
Grade 4 (All)	49%	43%	30%	51%	59%
Grade 4 (female only)	53%	47%	33%	48%	67%
Grade 5 (All)	52%	46%	31%	39%	56%
Grade 5 (female only)	56%	50%	33%	36%	54%

Note. (*2018 SBAC-CAASPP*, 2019)

During the 2018-2019 school year, Table 3.3 and Table 3.4, the percentage of female 4th and 5th grade students in the STEM school, who met or exceeded state standards, was much higher than the percentage of female 4th and 5th grade students at the non-STEM school. However, in third grade the non-STEM school's female students had higher scores than the STEM score in ELA and mathematics. Note that grade levels were not organized into cohorts, which meant their data reflected different groups of students. This means, for example, that grade 3 was not the same group of students in grade 4.

Table 3.4. 2018-2019 Mathematics- Smarter Balanced Assessment Consortium Achievement Percentage of Students that Exceeded and Met

	State	County	District	Non-STEM	STEM
Grade 3 (All)	50%	43%	28%	60%	44%
Grade 3 (female only)	49%	42%	26%	66%	29%
Grade 4 (All)	44%	37%	23%	37%	51%
Grade 4 (female only)	43%	35%	22%	32%	47%
Grade 5 (All)	38%	29%	15%	22%	30%
Grade 5 (female only)	36%	28%	14%	16%	31%

Note. (2019 SBAC-CAASPP, 2019)

In addition to the ELA and mathematics assessments, the California Science Test (CAST) was administered to all 5th grade students in the state. The 2018-2019 academic year was the first year that the CAST was administered for accountability purposes and is only assessed in grade 5 in elementary schools. Table 3.5 shows the results for all fifth grade students across the school district and provides the results for female students.

Table 3.5. 2018-2019 Science- Smarter Balanced Assessment Consortium Achievement Percentage of Students Total Exceeded and Met

	State	County	District	Non-STEM	STEM
Grade 5 (All)	32%	25%	13%	17%	37%
Grade 5 *(Female only)*	32%	25%	13%	16%	29%

Note. (*2018 SBAC-CAASPP*, 2019)

During the 2018-2019 academic year there were significant changes in the school district which may account for the significant drop in performance in ELA and mathematics at the STEM school compared to the students' performance in previous years. Both schools still showed higher percentages compared to the county and school district SBAC scores. In 2018-2019, 51% of these students, now in grade 4, met or exceeded the state standards. The ELA performance results for the STEM school with the same group of students from grade 3 in 2017-2018 went from 50% to 59% in grade 4. This reflected a much better result than that produced by the non-STEM students. Students also, at the STEM school, outperformed the non-STEM school on the CAST. These data are recognized to show similarities and differences of the two schools that were included in the research.

Research Methodology

The research was conducted in two schools in a small elementary school district, located in Southern California. The treatment school was the STEM school that employed PLTW since 2014. Both schools are parent choice or alternative schools. One school had a STEM magnet program the other an Art magnet program. The STEM magnet school adopted the Project Lead the Way (PLTW) Launch Curriculum (PLTW, 2017) across the K-5 grade levels.

California Education Code Section 58501 stated that an alternative school shall offer students the benefit of learning independently, in groups, or both, with teacher guidance and support in educational choices (*Law section: California Ed. Code 58500*, n.d.). Alternative, or parent choice, schools expect that parents and their children were choosing the school based on a thematic learning experience. Examples of parent choice school themes were STEM, performance and visual arts, or foreign language. This was important because families who chose a magnet school had an increased value on learning with a thematic based program than those who are not attending the choice school. There was also an understanding that parents would be actively involved in their student's learning (Archer et al., 2013; Leaper et al., 2012; Senge et al., 2012). The researcher looked at both schools through a quantitative lens.

This was a quantitative, correlational design study with purposive sampling that examined whether or not engagement in STEM related curriculum, i.e., PLTW Launch curriculum in this study, correlated with girls' perceptions and career interests in STEM.

The correlational, non-experimental design was appropriate because the variables were not manipulated. The non-experimental approach allowed the researcher to compare two groups in their natural environments (Creswell, 2014; Howell, 2017; Wallen, 2014).

The target group (PLTW) of girls is the STEM school and comparable (non-PLTW) group of girls is the non-STEM school. To answer Research Question 1, i.e., "What is the correlation between STEM perceptions and STEM career interests for the STEM (r_S) and non-STEM (r_{NS}) school girls'? More specifically, are the correlations between STEM perceptions and STEM career interests for the two groups equal?

" the researcher used the Pearson product-moment correlation to examine the strength and directionality between the two variables (Howell, 2017). For Research Questions 2 and 3, "What is the difference in means between STEM perceptions of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls who had no exposure to the STEM PLTW Launch Curriculum?" and "What is the difference in means between STEM career interests of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that had no exposure to the STEM, PLTW Launch curriculum?," independent t-tests were used to test the null hypotheses of no difference between the group means of the two groups on each variable i.e., perceptions and career interest in STEM. Descriptive statistics i.e., means, median and standard deviations, were obtained for each of variable.

Sampling

The target population included students in the non-STEM school students in fourth and fifth grade (*n*=190) and the students in the STEM school (*n*=196) (CDE's 2017-2018 information, (Dataquest, 2019). The sample included only fourth and fifth grade girls from the 2018-2019 school year. Students were invited to complete the online survey at summer school. Due to the low number of students who volunteered to participate in the summer, additional data were collected in October 2019 and then again in in February 2020. A total of 47 female students from the STEM magnet school and 18 female students from the Art magnet school completed both the Semantics survey and the Career Interest Questionnaire.

The researcher received written permission from CSUSB's Institutional Review Board (IRB) (Appendix H), and from the school district and school site administrators to employ the online STEM Semantics Survey (APPENDIX A) and the STEM Career Interests Questionnaire (APPENDIX B) (Christensen et al., 2011; Knezek et al., 2012; Tyler-Wood et al., 2011; *UNT Instruments,* 2019.

The researcher trained an individual at each school to administer the survey in each section of the two grade levels. These individuals first read the student assent statement to all students. The survey administrator then directed students to the two surveys that were administered online using Qualtrics. The individual then went over the instructions after the asset was read. Students used their district ID numbers as this number travels with students from school to school. Students identified their elementary school name, their current grade level, and their gender. The ID numbers were only used to manage whether students took both surveys to allow for correlation of data.

Instrumentation

The two surveys that were implemented in the study were, (1) STEM Semantics Survey (Christensen et al., 2011; Knezek et al., 2012; Tyler-Wood et al., 2011; *UNT Instruments,* 2019) and (2) the Career Interest Questionnaire (Bowdich, 2009; Kier et al., 2014; Tyler-Wood et al., 2011; *UNT Instruments*, 2019). The Career Interest Questionnaire was modified by replacing the word “science” with the words “science, technology, engineering and mathematics (STEM).” There are three parts to the questionnaire; Part 1, with five items, career focused and aspirations in STEM; Part 2 focused on the students confidence in science ability in college or career and Part 3 feelings about a career in STEM (Tyler-Wood, et al., 2011). Additional modifications included inserting an item in Part 1, thus increasing the number of items from 13 statements to 14 statements. The questionnaire included a total of 14 statements. Students were required to rate each statement according to a Likert scale with the following categories: Strongly disagree (SD), Disagree (D), Undecided, (U), Agree (A) and Strongly agree (SA).

The STEM Semantics Survey is a 7-point semantic differential instrument with opposite adjectives on the extremes of the scale. For example, one end of the scale had the word ‘exciting’ with a rating of 1 and the other end of the scale had the word *‘unexciting’* or its antonym with a rating of 7. The ratings were reverse scored to reflect the directionality of the construct, i.e., that a higher rating indicates a more desirable perception toward the concept. Statements that were presented with the negative adjective at the left and the positive adjective at the right were kept the same. The participants were required to choose the number value that was closest to the adjective that best described her attitude toward five domains i.e., science, math, engineering, technology and careers.

The STEM Semantics Survey was developed to be beneficial for both teachers and students. In this study, however, only students took the surveys. Both the STEM Semantics Survey and the Career interest Questionnaire were developed to address the Innovative Technology Experiences for Students and Teachers (ITEST) to respond to the lack of workers in STEM fields (Parker et al., 2010).

To develop the instrument, Tyler-Wood, Knezek and Christensen (2011) viewed instruments in the Mental Measurement Yearbook (MMY), including Novodovorsky’s instrument that was developed with 20 items across 3 factors measuring science interest and perception. The 3 factors were:

1) Interest in science classes and activities in science classes

2) Confidence in ability to do science, and

3) Interest in science-related activities outside of school

Novodovorsky (1993) instrument did not meet the needs of elementary school students. Since there was no survey that addressed STEM perceptions and career interests in elementary students, Tyler-Wood et al. (2011) developed the STEM Semantics Survey and the Career Interest Questionnaire. The instruments were useful for assessing students at the elementary school level with items that could be understood by students with ease (Tyler-Wood et al., 2011). Both surveys have been published and are available to the public on the University of North Texas, Institute for the Integration of Technology into Teaching and Learning website.

In preparation to administer the surveys letters were sent home to parents/guardians of all grade 4 and 5 students for their permission to administer the survey. Survey administrators read the assent form to the participants so that students understood that the survey and questionnaire were optional, and that if they chose to not take the survey it would not count against them.

Students were then asked to log in to Qualtrics to access the online survey and questionnaire. Both the STEM Semantics Survey and the STEM Career Interests Questionnaire were delivered through Qualtrics. The survey data were password protected and housed in the cloud. Gender, age, grade, student lunch ID, elementary school of attendance, and the grade the student started at the elementary school were requested on the surveys.

Data Analysis

The data were downloaded from Qualtrics into Microsoft Excel® and organized to be used in WINSTEPS® (Linacre, 2018) for data analysis with the Rasch Model. George Rasch (1960) developed this measurement model and is arguably "… applicable in literally any field of science" (Rasch, 1968, p. 26) whether qualitative or quantitative. The Rasch model is conducive for analysis of "rating and ranking scale instruments" (Boone et al., 2011, p. 260) in science education. The Rasch model allows the researcher to examine the psychometric properties of student responses and items. Furthermore, the output files allow the researcher to examine the data from a qualitative lens through critical thinking and reflection.

The Rasch model looks at variation in the data. The model is considered as stochastic or probabilistic. Winsteps transforms ratings which are ordinal to interval/measurable data (Winsteps, 2020).

The Likert Scale for the Career Interest Questionnaire survey (CIQ) is set up as ordinal data. The ordinal scale data that used the ratings of SD, D, U, A and SA for each item were transformed to the natural logarithm or interval data (Bond & Fox, 2015, p. 30). Changing from raw scores to interval data is important because the value of each Likert response are presumed interval and does not take into account the subjectivity of the data (Bond & Fox, 2015). The order of the data stays the same after being converted to interval data. The meaning of the data needs to be preserved during data analysis; interval data preserves the data and allows for further analysis with t-tests, fit statistics, Pearson's R (Harwell & Gatti, 2001).

WINSTEPS provided summary statistics such as means, standard deviations, standard errors of measurement, fit statistics and reliability coefficients. Pictorial diagrams, called Wright or Variable maps provided a 'item-person' map showing the positional relationship of the ability measures of individuals who responded to the survey to the item calibrations. The Variable map is the visual of the logit measures for both the CIQ and Semantics survey with the participants (persons). The persons on the map are represented by a letter and numbers. The first letter represents STEM (S) or non-STEM (N) the rest of the numbers represent students from 1 to 47 for the STEM school and 1 to 18 for the non-STEM school.

The persons, left side of the map is the location of <more> and <less> and the item side, right, is <rare> and <freq> from top to bottom respectively.

Additionally, the 'Misfit" tables, showed how well the data fit the Rasch model. The infit/outfit ZSTD is the standardized fit statistics of person *n* in relation to the number of items person *n* responded to.

The outfit ZSTD for each item was examined before the Infit MNSQ. Values greater than +2 were indicative of the response patterns not fitting the

Rasch model. These response patterns included more variation in them than expected. Similarly, items that had Outfit MNSQ below -2 were considered to include less variation in them than expected. The MNSQ data are listed in Appendix C, D, E and F. ZSTDs less than 2 overfit the Rasch model and ZSTDs greater than 2 underfit the model (Bond, 2015, p. 271). The large ZSTDs were considered to be of greater significance to the fit of the data to the Rasch model than the low ZSTDs. The ZSTD date discussion are listed in chapter five and data are listed in Appendix C, D, E and F.

The interval scale data obtained from Winsteps were exported to SPSS to obtain the Pearson's R correlation to answer question one. This bivariate correlation reported the relationship between the two variables, the Semantics survey and the Career Interest Questionnaire. Pearson's correlation coefficient views the relationship as positive, negative or 0 (Mertler & Reinhart, 2016; Muijs, 2011). Additionally, a *t*-test was conducted to view the significant differences between group means for research questions two and three.

Reliability and Validity

The RASCH model provided answers to the questions of validity and reliability as the ordinal data (i.e., student ratings) are converted to equal-interval data; the raw data becomes linear (Boone et al., 2011; Rasch, 1968). Validity is supported by examining the fit of the data to the Rasch model. Winsteps provides

Rasch reliability coefficient for both the student responses and for item calibrations.

Positionality of the Researcher

The researcher holds a post-positivist worldview through a feminist, science lens. With a post-positivist lens the researcher starts with a theory and data collection that will either refute or support the theory (Creswell, 2017). Western culture and influence in science is dominant, and women's points of view are sometimes considered irrational, representing an obstacle in the scientific community (Harding, 2006, 2008; Mayberry & Rees, 1997). The researcher's worldview holds the belief of a post-positivist, feminist, science view that helps with social justice in giving girls access to science, technology, engineering and mathematics and a voice in contributing to the STEM community.

As a post-positivist, the researcher believes that a cause determines the outcome and evidence will support or refute the hypothesis (Creswell, 2014). The history of Western science beliefs argues that women have the same opportunities in science as men and that removing barriers for women in science has already occurred. This type of equality does not mean equity in STEM. Harding (2016) argues that being part of the candidate pool isn't enough; women need to be appointed to professional membership leadership roles, STEM teaching positions, and political roles and given deserved STEM awards. Men are still the leaders and influencers in science in the “manpower” pool of candidates in STEM. It is not just that women have access and are in the selection pool of STEM careers but need to be part of the decision making process (Harding, 2016).

Summary

Girls who have increased perceptions in STEM are more likely to have a higher efficacy in STEM and choose careers in STEM. The next chapter will show the results of this quantitative correlational research study.

CHAPTER FOUR

RESULTS

Introduction

The purpose of this correlational, non-experimental study was conducted to determine if girls' STEM perceptions and career interests were higher for those who were exposed to STEM curriculum such as the PLTW's Launch STEM curriculum compared to those who did not have exposure to STEM curriculum. This chapter presents the results of the quantitative study that investigated elementary 4th and 5th grade girls' perceptions and career interests in STEM.

This chapter is organized as follows: the Rasch analysis of data, including Variable maps and the infit/outfit tables, and finally the three research questions are addressed with Pearson's correlation for the first question and t-tests for the final two questions. Statistical significance was assessed at $ά = .05$.

Background Data

Data were gathered from the participating STEM school and the non-STEM school via a survey deployed through Qualtrics. Although the study focused on female students, both the Career Interest Questionnaire (CIQ) and the Semantics differential survey were offered to the male and female students at the two schools. A total of 122 participants responded to the CIQ, and a total of 117 participants responded to the Semantics survey. For the purposes of these data analyses, only data from female students were used. The non-STEM school had a total of 18 female participants and the STEM school had a total of 47 female participants who took both surveys. If female students only responded to one survey, the data were not used. This affected the sample size because there would have been more available data for both the CIQ and the Semantics surveys if participants did not take only one survey. Question one needed to have data to correlation between the surveys.

The participants were either in grade 4 or grade 5 during the 2018-2019 school year. Microsoft Excel®, Winsteps® and SPSS® software programs were all used to organize and analyze the data. Excel was first used to remove male students from the data set and check for missing items. To establish anonymity of the participants, information such as student IDs, date of submission, and Qualtrics tracking were removed. The data were then formatted in Notepad® for use in Winsteps. Winsteps was used to transform the rating scale data (i.e., ordinal in nature) to interval data, allowing for the development of measured data. Finally, SPSS was used to conduct statistical analyses including obtaining descriptive statistics, effect size or Cohen's D (pooled S.D), and the correlation between the CIQ and Semantics survey data. An Independent t-test was used to exam analyze the significance for STEM and non-STEM participants on the CIQ and also on the Semantics Survey.

Data Analysis

The Likert type responses from the CIQ and the semantic differential responses from the STEM Semantic Survey produced rank-order data and not interval scale data. The Winsteps software program (Linacre, 2018) that uses the Rasch measurement model converted the raw scores i.e., ratings, to interval scale data. These data maintain their numerical meaning.

The Rasch logit scale, "… is the measurement unit common to both person ability and item difficulty" and is displayed along the left of the pictorial Wright map (Bond & Fox, 2015, p. 67) with equal sized units along the vertical line (Bond & Fox, 2015). All measures on the scale were deemed to be continuous and intervals with an arbitrary zero established at the mean of the item calibrations.

The Rasch Analysis is a probabilistic model (Bond & Fox, 2015; Karabatas, 2001; Newby et al., 2009). Included in this section is the Rasch analysis for both the Career Interest Questionnaire and the Semantics Surveys.

Rasch Output Data

The data were collected via two surveys, the STEM Semantics survey and CIQ survey (Tyler-Wood et al., 2011). Sixty-five students took both the (a) Career Interest Questionnaire (CIQ) and (b) the STEM Semantics surveys. The ensuing data were polytomous, meaning each item had more than two possible scores. There were 14 items on the CIQ survey and 25 items on the Semantics survey. The CIQ (Appendix A) was organized into interest in STEM college programs and careers in STEM.

Variable Map

In theory, the variable map scale range from negative infinity to positive infinity (Bond & Fox, 2015). The Variable map and the table of summary statistics report the range for the item calibrations and person perceptions. Persons who succeed in answering items that were higher on the logit-scale have a better than 50% chance of answering items that are lower on the logit-scale. Persons higher on the scale found the survey items to be easy. Persons S19 and S26, for example, found the survey statements to be extremely easy to agree to compared to persons S09, N08, S39, S42 and S46.

Item Q10 is the most difficult item on the survey. The easiest to endorse items were located between 0 and -1 logits. These items were targeted for a small number of participants (persons) (i.e., N08, S39, S43, S46, and S09) located at the bottom of the scale. The least difficult item on the survey was Q18.

Table 4.1. Semantics Survey – Variable Map

```
INPUT: 65 SS   26 QS   MEASURED: 65 SS   25 QS   7 CATS            WINSTEPS 3.68.2
--------------------------------------------------------------------------------

                                     SS - MAP - QS
                                     <more>|<rare>
    2                             S19 S26  +
                                           |
                                           |
                                      S40  |
                                      N14  |
                                           |
                                          T|
                                      S42  |
                                           |  Q10
                                      N03  |
                                      N15  |
                                  S15 S36  |
    1                             N02 N10 S+
                          N05 N18 S10 S21  |
                                      S33  |
                                           |
                      N06 N12 S07 S18 S41  |T
                              S11 S37 S47  |
                      N16 N17 S04 S24 S44 M|
                      N09 S02 S20 S25 S27  |
                  N01 N04 N11 S03 S06 S23  |S Q8
              S01 S05 S08 S17 S22 S30 S34  |  Q9
      S12 S13 S14 S16 S28 S31 S32 S38 S45  |  Q7
                          N07 N13 S29 S35 S|  Q1   Q12  Q4
    0                                      +M Q11  Q2   Q20  Q25  Q5   Q6
                          N08 S39 S43 S46  |  Q13  Q14  Q23  Q24  Q3
                                      S09  |  Q19  Q22
                                           |  Q15  Q17
                                           |S Q16  Q21
                                          T|  Q18
                                           |
                                           |
                                           |T
                                           |
                                           |
                                           |
   -1                                      +
                                     <less>|<frequ>
```

Variable map (Table 4.2) shows that the CIQ items were not difficult for most participants. The person measures ranged approximately between -1 logit and 5 logits while the item calibrations ranged from approximately, -.56 logit to .60 logit.

Persons with attitude measures between 0.5 logits and 5 logits had much higher probability of endorsing i.e., agreeing to the items than persons below 0.5 logits. The average mean perception for the persons at 1.4 logits was much higher than the average mean item calibration at 0 logits. Person S265 was the person with the most positive perceptions while person N124 had the least positive perceptions toward STEM.

Item Q9 was the most difficult item on the survey, and Q4 was the least difficult item on the survey. In general, the Variable map shows that the items were extremely easy for the participants, spanned across a small range (i.e., between, -.56 logit to .60 logit) and not well targeted for this participant group. Visually the CIQ Variable map shows that the items were not difficult for most participants (persons). The mean calibration of the items, 0 on the logit scale, is extremely low on the scale compared to the mean perception measure of the persons, at 1.40 logits.

Table 4.2. Career Interest Questionnaire – Variable Map

```
INPUT: 65 SS   14 QS   MEASURED: 65 SS   14 QS   5 CATS            WINSTEPS 3.68.2
--------------------------------------------------------------------------------

                                          SS - MAP - QS
                                          <more>|<rare>
    5                                           +
                                                |
                                          S265  |
                                                |
                                                |
                                                |
                                                |
    4                                     S414  +
                                                |
                                                |
                                    S364  S434  |
                                               T|
                                                |
                                          S184  |
    3                                           +
                                    N104  S274  |
                                          N144  |
                                                |
                                          S074 S|
                  N184  S015  S234  S374  S425  |
                                                |
    2                                     S034  +
                                                |
      N074  S085  S134  S144  S214  S324  S384  |
                        N015  S104  S314  S344  |
      N114  N174  S114  S124  S194  S354  S454 M|
                                    N055  N154  |
                  N044  S054  S204  S224  S404  |
    1       N025  N035  N134  S174  S244  S284  +
                                    S044  S154  |
                                          S064  |
                              N065  S254  S334  |T Q9
                        N095  S304  S444  S474  |  Q6
                                               S|S Q11
                                    S024  S394  |  Q10    Q12    Q8
    0                         N164  S094  S164  +M Q2     Q3
                                          N085  |  Q1     Q14    Q7
                                                |S Q13
                                    S294  S464  |  Q5
                                          N124  |T Q4
                                               T|
                                                |
   -1                                           +
                                          <less>|<frequ>
```

number of participants, the measure mean, the measure standards deviation (S.D.), the separation index and the reliability coefficients of the survey.

Sixty-five students took both the (a) Career Interest Questionnaire (CIQ) and (b) the STEM Semantics surveys. Table 4.3 provides the descriptive statistics for the participants who took the CIQ and the Semantics Survey; the CIQ mean measure was 1.40 logits with a standard deviation of 1.05 logits. The person separation Index was 2.07 giving a reliability coefficient of .81. Separation index is the ratio between the true standard deviation (i.e., adjusted standard deviation) and the root mean square error.

The descriptive statistics for the data from the 65 students who took the Semantics survey were as follows: The mean measure was 0.53 logits, with a standard deviation of 0.48 logits. The person separation index was 1.91 resulting in a reliability coefficient of .78.

The reliability coefficient and separation index for the CIQ were considered high while these indices of person separation and reliability were moderate for the Semantic differential.

Table 4.3. Summary Statistics for Participants (Participants, Mean, Standard Deviation, and Reliability)

Survey	persons	Measure Mean[1]	Measure S.D.[1]	Separation Index	Reliability Coefficient
CIQ	65	1.40	1.05	2.07	.81
Semantics	65	.53	.48	1.91	.78

Note. [1] Data are in logit units.

Table 4.4, Summary Statistics for Persons (CIQ) lists the number of questions, mean calibration in logit units, S.D., and the reliability coefficients of the survey items. The mean calibration for the items is arbitrarily set to 0 logits. The CIQ item standard deviation is 1.05 logits with a reliability coefficient of .81 and the semantics survey standard deviation is .48 with a reliability of .78.

The standardized fit (ZSTD) summary statistics for persons on the CIQ are as follows: the mean infit was -.2 and the outfit was -.2 and the standard deviation (S.D.) for ZSTD infit was 1.70 and outfit was 1.70. The expected ZSTD is 1. The obtained values were indicative of the data fitting the Rasch model. The real mean square (RMSE) for the CIQ (persons) was 0.46 which are the, difficulties and abilities; standard errors of measure estimates (Winsteps, 2020).

The standardized fit (ZSTD) summary statistics for persons for the Semantics survey are as follows: the mean infit is .0 and the outfit is .0 and the standard deviation (S.D.) for ZSTD infit was 1.6 and outfit was 1.7. The Outfit ZSTD was indicative of the data fitting the Rasch model. The real mean square (RMSE) for the Semantics survey was 0.23.

The standardized fit (ZSTD) summary statistics for items on the CIQ are as follows: the mean infit was -.1 and the outfit was -.1 and the standard deviation (S.D.) for ZSTD iinfit was 1.9 and outfit was 1.9. The standardized fit (ZSTD) statistics were indicative of the data fitting the Rasch model. The real mean square for the CIQ items was 0.18 which are the difficulties and abilities; standard errors of measure estimates (Winsteps, 2020).

The standardized fit (ZSTD) summary statistics for items on the Semantics survey are as follows: the mean infit is .0 and the outfit is -.2 and the standard deviation (S.D.) for ZSTD infit was 1.7 and outfit was 1.8. Again, the standardized fit statistics were indicative of the item data fitting the Rasch model. The real mean square for the Semantics survey was 0.10.

Research Questions

The three research questions are listed below:

1. **Research Question 1:** What is the correlation between STEM perceptions and STEM career interests for the STEM (r_S) and non-STEM (r_{NS}) school girls'? More specifically, are the correlations between STEM perceptions and STEM career interests for the two groups equal?
2. **Research Question 2:** What is the difference in means between STEM perceptions of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls who had no exposure to the STEM PLTW Launch Curriculum? **H_{02}:** $\mu_S - \mu_{NS} = 0$
3. **Research Question 3**: What is the difference in means between STEM career interests of STEM (μ_S) girls who had exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that had no exposure to the STEM, PLTW Launch curriculum?

Hypothesis 1

H_{01}: $\rho_S = \rho_{NS}$

This null hypothesis states that there is no difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

H_{11}: $\rho_S \neq \rho_{NS}$.

The alternative hypothesis states that there is a difference in the population correlations between STEM perception and career interests obtained for the STEM (ρ_S) and non-STEM students (ρ_{NS}).

The logit measures from both surveys were correlated using SPSS, bivariate/Pearson's coefficient (*r*). Additionally, the STEM school (N_S=47) and non-STEM school (N_{NS}=18) data were analyzed separately for each school and correlation coefficients obtained.

The non-STEM schools Pearson correlation coefficient between the logit measures (n=18) for the Semantics survey and the CIQ was .425 (p = .079) and the STEM school's Pearson correlation coefficient between the logit measures (n=47) for the Semantics survey and the CIQ was 0.374 (p=.010). Both the STEM and non-STEM school had positive correlations, however, the correlation for the non-STEM school was stronger than the correlation for the STEM school. The correlation coefficient for the STEM school was statistically significant at the .05 level of significance. Statistical significance is a function of sample size. The non-statistically significant result for the non-STEM school could be the result of the sample being very small (n_{ns}= 18).

The Fisher's z-transformation was used to test the null hypothesis that the correlation coefficients between Semantics Survey and the CIQ, obtained from two independent samples i.e., the STEM and non-STEM girls, are equal. The obtained Fischer's z of 0.20 with a p-value of 0.58 was statistically not significant at the .05 level. It can therefore be concluded that there is no evidence to suggest that the correlation coefficients came from two separate populations. The null (H_{01}) hypothesis was accepted for question one.

Hypothesis 2

H_{02}: $\mu_S - \mu_{NS} = 0$

There is no difference in the population means in STEM perception for STEM and non-STEM students for the two groups.

H_{12}: $\mu_S - \mu_{NS} \neq 0$.

There is a difference in the population means in STEM perception for STEM and non-STEM students.

The second null hypothesis was tested by conducting an independent t-test of the means of student measures from the Semantics Survey with an alpha-value set at 0.05. Descriptive statistics for the STEM participants (n=47) and the non-STEM participants (n=18) are listed in Table 4.4. Table 4.4 highlights the descriptive statistics for the CIQ survey for STEM and non-STEM school participants. STEM school participants (*n* = 47) had a mean of 0.49 logits, a median of 0.31 logits and a standard deviation of 0.49 logits. Non-STEM school participants (*n* = 18) had a mean of 0.65 logits, a median of 0.56 logits and a standard deviation of 0.48 logits. The results of the independent t-test are shared in Table 4.5a. The significance for the Semantics survey was $p = 0.21$, the mean difference is -0.16, the standard error difference is 0.29, and the 95% confidence interval of the difference is (lower) -0.27 and (upper) 0.90. The value of zero falls between the upper and lower limits of the confidence interval.

Table 4.4. Descriptive Statistics: Semantics Survey

	N=	Mean	Median	S.D.
STEM	47	0.49	0.31	0.49
Non-STEM	18	0.65	0.56	0.48

Note. The data are in logit measures.

The test of the null hypothesis for the Semantics survey (i.e., H_0^2: $\mu_S - \mu_{NS} = 0$) with the mean of the STEM participants 0.49 and the mean of the non-STEM participants 0.65 resulted in a statistically non-significant result ($p>.05$). There was not sufficient evidence to accept the alternative hypothesis (i.e., $H_{02:}$ $\mu_S - \mu_{NS} \neq 0$). The obtained mean of the comparison group being larger than the mean of the target group could be a function of the small sample size of the comparisons group.

Table 4.5. Independent Samples t-test: Semantics Survey

t	df	Sig (2-tailed)	Mean difference	Std. Error	Confidence Interval Lower	Confidence Interval Upper
-1.24	63	0.21	-0.17	0.13	-0.44	0.10

The American Psychological Association recommends that effect sizes be reported for research even when there is no statistical significance (APA, 2010, p. 32). Cohen's d provides a measure of the educational importance of the difference in means in terms of the pooled standard deviation. Reporting effect sizes become even more important since this study had a small sample of student (Research by Design, 2020). The Cohen's d effect size for the Semantics survey was -0.33.

Hypothesis 3

$\mathbf{H_{03}}$: $\mu_S - \mu_{NS} = 0$

There is no difference in the population means in STEM careers for STEM and non-STEM students.

$\mathbf{H_{13}}$: $\mu_S - \mu_{NS.} \neq 0$

There is a difference in the population means in STEM careers for STEM and non-STEM students.

Table 4.6 provides the descriptive statistics for the CIQ survey for the STEM and non-STEM school participants. The STEM school participants (*n* =

47) had a mean of 1.48 logits, a median of 1.43 and a standard deviation of 1.10. The non-STEM school participants (n = 18) had a mean of 1.17, a median of 1.22 and a standard deviation of .91. The significance for the CIQ survey is p = 0.29 with a p-value set at 0.05, the mean difference is 0.31 the standard error difference is 0.29 the 95% confidence interval of the difference is (lower) -0.27 and (upper) 0.90.

Table 4.6. Descriptive Statistics: Career Interest Questionnaire STEM and Non-STEM Participants

	N=	Mean[1]	Median[1]	S.D. [1]
STEM	47	1.48	1.43	1.10
Non-STEM	18	1.17	1.22	.91

Note. [1]the unit of measures is the logit.

Table 4.7. Independent Samples t-test: Career Interest Survey

t	df	Sig (2-tailed)	Mean difference	Std. Error	Confidence Lower	Confidence Upper
1.07	63	0.29	0.31	0.29	-0.27	0.90

Table 4.7 showcases the probability of obtaining a mean difference of 0.31 by chance i.e., p= 0.29. The standard error of the means was 0.29 resulting in a confidence interval of (-0.27) and upper (0.90) for including the population mean. The results of the t-test showed that there was not sufficient evidence to accept

H_{13}: $\mu_S - \mu_{NS.} \neq 0$; the null hypothesis was accepted because the p-value, 0.29 did not show statistical significance ($p > 0.05$). The Cohen's d effect size for the CIQ measures, with the standard deviation of the comparison group, was 0.34; the magnitude of d is a medium effect.

Summary

This chapter detailed the test of the hypotheses established for the study. The t-test was used to determine if the 4th and 5th grade female students at a STEM school would have statistically significantly higher perceptions of and interest in STEM. For this sample of participants, the first null hypothesis was accepted based on significance of $p = 0.05$. For questions 2 and 3, the null hypotheses were accepted where the p-values were greater than .05. In Chapter Five the findings are discussed to examine possible limitations of the study results, next steps in research, and recommendations for educational reform.

CHAPTER FIVE

RECOMMENDATIONS AND CONCLUSIONS

Overview

This chapter provides an overview of the research study, limitations of the study, findings, recommendations for educational leaders, educational reform, future research, and conclusion.

<u>Background</u>

Self-efficacy, is the perceived belief that a person has the "capacity to execute behaviors necessary to produce specific performance attainments" (Bandura, 1993; Carey & Forsyth, 2009, p. 1). Girls' self-efficacy and their perception in STEM starts before students attend school; girls come to school with an increased level of self-efficacy in STEM (Lamb et al, 2015). Students are influenced as soon as they enter elementary school (Gunderson et al., 2012). Students who gain access during adolescence can self-efficacy in an academic domain (Lamb et al., 2015; Wang, 2013).

The Next Generation Science Standards states that curricular decisions has an impact on girls' affinity, achievement and confidence in STEM (NGSS, 2013). The NGSS case study number 5, *Girls and the Next Generation Science Standards stated that* "It underscores how the purposeful inclusion of effective strategies for girls can have a positive impact on their confidence as beginning scientists and engineers" (NGSS California, 2013, pg. 1). McElheny (2017) in

Closing the Gap: Improving Girls' Retention in STEM stated that science gap for girls and boys has a negative impact on women in STEM careers starting in middle school and continues throughout high school. The career interests of girls in STEM starts to decline in perception and self-confidence. There is then a loss of self-efficacy which is obtained through tangible and social experiences in science (Bandura, 1993). Girls in science and engineering remove themselves from the STEM pipeline because of the decline in their self-efficacy (Blickenstaff, 2005). It is stated that girls that engage in PLTW course in middle school had an increased effect on their self-efficacy in STEM (McElheny, 2017).

The current research study is a correlational design, non-experimental approach with a post-positivist worldview through a feminist, scientific lens (Creswell, 2014; Harding, 2016). The purpose of this study was to compare the perceptions toward STEM and the career interests in STEM fields of female 4th and 5th grade students that attended a STEM magnet against those of female students at a non-STEM school. The study also looked at just the perceptions and the career interests of STEM and non-STEM female participants.

Limitations of the Study

This study was limited to being able to access only 18 non-STEM participants and 47 STEM school participants; the statistical procedures did not have sufficient power to result in statistical significance for all three null hypotheses. The small sample size is one characteristic of the design that negatively impacted this study. Other factors may also have impacted the results of this study. For example, teacher and parent influence on who participated may have biased and limited the outcome of the research. Administering the surveys was challenging due to conflicts in student and teacher schedules. On any given day the classroom teachers' schedule changed or students were not available due to school-mandated common formative assessments or examinations.

Environmental factors could have influenced the non-STEM school participants' on how they responded on the surveys. These participants may have parents that have non-traditional careers or who do not support STEM interest (Jacobs et al., 2009). Female students who have mothers with non-traditional careers are more likely to have high perceptions about STEM (Piatek-Jimenez, 2008; Piatek-Jimenez et al., 2018). These students may have been highly influenced by the topic of the research and chose to take the survey because STEM is already an area of interest. Other non-participants could have chosen not to take the survey or may not have been allowed to get permission from parents because the research was only looking at data from females and STEM was not an area of their interest. The title itself may have deterred the level of engagement among the participants.

Interpretation of Results

<u>Question One</u>

The first question examined in the study was, "What is the correlation between STEM perceptions and STEM career interests for the STEM (r_S) and non-STEM (r_{NS}) school girls'? More specifically, are the correlations between STEM perceptions and STEM career interests for the two groups equal?"

When the correlation between the Semantics survey and the CIQ survey were obtained for each sample of students, the results showed that the girls from the non-STEM school (n = 18) had a correlation of 0.425 that was not statistically significant (p = .079). The correlation coefficient of 0.374 for the girls from the STEM school (n=47), although smaller than the correlation for the non-STEM school the obtained correlation of 0.374 was statistically significance with p = .010). The non-STEM and STEM participants have a positive linear correlation. (Muijs, 2011). This means that as the non-STEM and STEM participants' have an increase in perceptions toward STEM their career interests also increased.

Based on Fisher-z of 0.20, and the p-value of 0.58, there was no reason to reject the null hypothesis of the difference in population correlations i.e., $\rho_S - \rho_{NS}$ between the STEM (r_S) and non-STEM (r_{NS}) school girls' STEM perceptions and their STEM career interests.

The results indicate that both the non-STEM and STEM school participants demonstrated positive perception in STEM and showed an understand STEM careers in relation to how they feel about STEM. It does not seem to matter if students had of did not have access to the Project Lead the Way experiences. Participants across both schools showed a positive relationship between STEM perceptions and interests in STEM careers. This is consistent with the notion that young children generally feel that those who have positive perceptions about science and mathematics also have an inclination toward careers in those fields. The question still remains if this relationship will continue with them into higher grade levels and college education. Yager and Penick (1986) stated that the environment where students learn influences girls' STEM career interests which are dependent on their perceptions. This was not the outcome and did not work out for this sample of participants. This research endorsed that girls have aspirations toward STEM careers whether they were exposed to the STEM PLTW curriculum or not.

Question Two

The second question examined in this study was, "What is the difference in means between STEM perceptions of STEM (μ_S) girls who have exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls who have no exposure to the STEM PLTW Launch Curriculum?"

The sample sizes were very small STEM (n=47) and non-STEM (n=18) and could have affected the statistical significance of the result. The p-value was not statistically significant. The effect size (Cohen's d) of -0.33 standard deviations showed a moderate differential between the means in standard deviation units. The negative Cohen's d could be a result of the John Henry effect. There may have been an experimental bias because of their understanding of being part of the control and not the target group. The non-STEM school may have felt they needed to over perform (Saretsky, 1974).

The null hypothesis for the difference in means was accepted because the *p*-value of 0.21 was much higher than the set alpha level of 0.05. The mean (0.49) of the STEM/PLTW participants minus the mean (0.65) of the non-STEM participants was not equal to zero. The difference in perception means, between This could mean that that participants in this study of elementary girls have a perception in STEM based on family and peer values (Bandura, 1993; Gunderson et al., 2012; Lamb et al., 2012; Osborne, 2010; Piatek-Jimenez, 2008; Wang, 2013). Leaper, Fargas and Brown (2012) suggest that girls' motivation and perception in mathematics and science are rated positively in elementary school. Girls who have parental and peer support in mathematics and science have a strengthened perception and motivation in STEM (Eccles & Wigfield 1993; Leaper et al., 2012).

Question Three

Question three was, "What is the difference in means between STEM career interests of STEM (μ_S) girls who have exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that have no exposure to the STEM, PLTW Launch curriculum?"

The Career Interest Survey displayed a moderate effect size of 0.32 and a p-value of 0.29. The difference in means between STEM career interests of

STEM (μ_S) girls who have exposure to the STEM, PLTW Launch curriculum and non-STEM (μ_{NS}) girls that have no exposure to the STEM, PLTW Launch curriculum was higher for the STEM participants than the mean of the non-STEM participants. However, due to the p-value of 0.29 being greater than .05, the null hypothesis was accepted suggesting that there was not sufficient reason to reject the null hypothesis. The difference in means could be an artifact of the small sample size. There was not enough evidence to reject the null hypothesis for question three.

The null hypothesis for all three questions was accepted. A student's self-perception of how they feel about a domain, such as STEM, art, reading or writing may be influenced by outside factors other than school curriculum. Furthermore, the self-efficacy and perceptions of a child's choice in careers are highly influenced by teachers, peers, parents and school environment at a young age (Lamb et al., 2012). Additionally, family values are more influential than the attitudes or perception of child in science (Jacobs et al., 2006; Lupart et al., 2004). It may be possible that the sample of participants already had positive perceptions and career interests in STEM. A child's perceived occupational perception may help with their choice in careers; the extrinsic values of a family could be more influential than the curriculum of either school (Bandura et al., 2001, Lamb et al., 2012).

Characteristics of Assessments

The variable maps for the Semantics survey (Table 4.1) and the CIQ (Table 4.2) showed that items were not well targeted to the children who took the surveys. The reliability for the items on the CIQ survey had a much lower reliability index than that for the Semantics survey. The Semantics survey showed a strong reliability and the CIQ survey demonstrates a moderate reliability coefficient. The Semantics survey has a high separation index and the CIQ has a moderate separation index. The separation index describes the ratio between the adjusted standard deviation i.e., standard deviation without error and the root mean square of the measures.

The items difficulties for the CIQ and Semantics surveys were spread over a narrow range. The item difficulties were not highly targeted for both groups of children. An instrument that is well-targeted "has a distribution of items that matches the range of the test candidates' abilities. Ideally, the mean and SDs of items and persons would match closely" (Bond & Fox, 2015, p. 372). The Semantics variable map (Table 4.1) showed that the average measures for the items did not match the average measures for the persons and the CIQ variable map (Table 4.2) average measure of the items also did not match the average measure of the persons. Both the CIQ and the Semantics survey need to be modified to enhance the validity of the research.

The infit and outfit ZSTDs are used to detect mis-fitting person and items response patterns (Bond & Fox, 2015, p. 270); see Appendices C, D, E and F for overfitting items and persons. If the items are overfitting the data there are more likely to have ‘too good to be true’ information (Bond & Fox, 2015; *Rasch Modeling*, 2020).

The CIQ infit/outfit (Appendix C) for items that are underfitting the model are as follows. ZSTD, infit and outfit items that are underfitting the model are items 11 and 14. These items are characteristic of a lot of noise and are over 2.0.

The Semantics survey items for infit/outfit (Appendix D) data for ZSTD are listed as follows: There are two items, 6 and 10, showed a lot of noise and are both underfitting the model for infit and outfit ZSTD. Items that underfit are usually unexpected and have unrelated irregularities; these data are too unpredictable (Winsteps, 2020). If the item is noisy (infit) the item could be considered extreme overuse and if the item is noisy (outfit) the item could be redundant (Winsteps 2020). Persons that underfit the model (infit) that are noisy could be a person that would typically is a qualitative different person. Persons that underfit the model (outfit) may not have finished the survey, only answered easy items or misunderstand the rating scale.

Appendix E showed the measures, infit/out MNSQ and infit/outfit ZSTD for persons on the CIQ. The ZSTD infit/outfit persons that underfit the model are 7, 13, 31, 48, 59, and 61. The infit/outfit MNSQ data are listed on Appendix E for review. Winsteps® takes infit/outfit (Appendix E, F) data out of the table that best fit the model when the infit/outfit tables are large (Winsteps, 2020). Outfit ZSTD for persons on the Semantics survey (Appendix F) showed the measures, infit/out. Persons 19, 26, 35, 45, and 46 overfit the model. When persons are high on the variable map the person may be careless or rushing on the survey and if the person is low on the variable map the person could be guessing (Winsteps, 2020).

Recommendations for Educational Leaders

Throughout the history of the United States, elementary schools are known for focusing on mathematics, English / language arts, social studies, and science. Usually, these subjects are taught in isolation. As educational leaders we have to question whether we stay with the status quo or look at how businesses access content and engage in problem solving. History also showed us that science and mathematics subjects are associated with males. The Common Core State Standards, fortunately, are neither masculine nor feminine. We must look at the curriculum that school districts adopt. Girls who have access to STEM in elementary school could possibly carry their career interests and perceptions in STEM into middle and high school (Lamb et al., 2015; Osborne, 2010). It is known that girls in elementary schools tend to have a higher self-efficacy and perception of themselves in STEM content knowledge and their belief that someday they will work in a STEM field (Bandura, 1993; Lamb et al., 2015). It was found in the research study that girls in elementary schools have STEM perception in STEM and career interests in STEM whether they have access to STEM curriculum or not. What can educational leaders do for girls during and after they leave elementary school? Suggested questions to answer are as followed:

Is the adopted district curriculum equitable for girls? Will girls feel like they are represented in the curriculum? Does the curriculum show girls in careers that are non-traditional? How will teachers and educational leaders continue to promote the perceptions and career interests of girls after they leave elementary school? Does having access to a STEM curriculum have an academic impact on state test scores for girls in elementary school

There is excitement in that girls have a perception in STEM and interest in careers in their adolescent years with or without a STEM curriculum. Because of this knowledge, policy makers should consider building on how to sustain and even enhance the perception and career interests in STEM into middle, high school and college. The factors that stop women from continuing into STEM careers could be from the environment after elementary school (Blickenstaff, 2005). The findings support the research literature that girls have positive perceptions in STEM and career interest in STEM at the elementary level (Bandura, 1993; Blickentaff, 2005; Gunderson et al., 2012; Jacobs et al., 2006; Lamb et al., 2012; Lupart et al., 2004; Osborne, 2010; Piatek-Jimenez, 2008; Wang, 2013).

However, there is research that states that girls who have access to STEM in elementary will have higher career interests in STEM (Shapiro et al., 2015). This would give cause for additional research and a larger sample size to be considered when taking both the Semantics and CIQ surveys. Including interviews (qualitative research) may have enhanced the validity of the results.

According to Shapiro et al. (2015), school leaders should take time in understanding current STEM polices for K-16. Schools that are considering adopting the PLTW, Launch curriculum should consider as examples the schools that have implemented PLTW and understand how the curriculum has impacted their community (Sorge, 2014). While this study did not show statistical significance in the difference of the STEM and non-STEM participants in perception or career interest, with this sample size, there is still something to be said about recommendations for STEM content and student learning. Girls who participate in a STEM program can increase their career options (Shapiro et al., 2015).

It is recommended that school leaders address the transition from elementary to middle school with regards to girls in STEM. How will educational leaders maintain the positive STEM perceptions of girls as the transition from elementary to middle school?

Next Steps for Educational Reform

Educators and leaders of school districts have the ability to empower girls in their educational interests and perceptions in STEM. This means that educators and district leaders are able to look at what curricula are influencing girls in the classroom. Girls have perceptions in STEM that correlated to their career interests at STEM and non-STEM schools with the research sample size in the study. However, students' perceptions and interest in STEM decline after leaving elementary school (Yager & Penick, 1986). Allowing children to explore their interests and giving positive feedback could allow students to choose their career and not let the beliefs of the educator or families detour them from STEM choices. Girls who have access to STEM curriculum could possibly continue to increase their perception and career interest in STEM (Eccles & Wigfield, 1993; Jacobs et al., 2002; Lamb et al., 2015).

Recommendations for Further Research

If offering the CIQ or Semantics survey it is recommended to consider adding more difficult items on both surveys. Consider sample size when using the CIQ and Semantics survey; the outcome of the participants may be different if the sample size is much larger. There may be change in the correlation between the non-STEM and STEM school participant perceptions and career interests when the sample size is much larger. More difficult items should be added to both the CIQ and Semantic survey to help with the item and person distribution on the variable map (*Rasch Modeling*, 2020; Winsteps, 2020). Another option may be to survey a non-STEM school that is not a parent choice school. When asking parents' permission, be sure to let them know you are looking for participants who enjoy STEM and who don't enjoy STEM.

PLTW was offered to the STEM School participants from kindergarten through grade 5. STEM curriculum that has been introduced to elementary schools may influence academics in science. The California Science Test (CAST) for fifth grade students may have a higher academic outcome with STEM curriculum that is embedded in everyday learning for students.

One recommendation would be to consider following a cohort of female students that are exposed to STEM education from elementary through their high school and college education experience. These data might show that girls' perception and career interests in STEM may stay intact compared to a group of girls that were not exposed to STEM in elementary school.

Another recommendation is that future researchers could look into the ELA, mathematics, and science academic performance of girls (schools) that have access to PLTW compared to girls (schools) that do not have access to PLTW. In Table 3.5, the STEM school, on the CAST, out-performed the state of California, the county, school district and non-STEM overall. When looking at just the female data, the STEM school out-performed the county, district and non-STEM school. This data, when correlated, may or may not show significance. Having access to STEM curriculum in elementary from kindergarten through grade 5, may have been an influence as to why girls at the STEM school out performed girls at the non-STEM on the state 5th grade science tests.

Also, the PLTW curriculum showcases both male and female characters. Looking at gender differences and a follow up to how this data correlates between non-STEM and STEM schools may have significant findings with an alternative sample group. Continued research in how PLTW schools compare to each other by using the CAST data by demographics for all subgroups including, but not limited to race, gender or socioeconomic status. The CAST data is now available for public consumption.

Conclusion

The results imply that girls that are exposed to the PLTW, Launch curriculum have relatively similar perceptions and career interests in STEM to girls who were not exposed to PLTW. This does not mean that STEM curriculums would not have had an impact nor does it mean that PLTW was the cause or not sufficiently efficacious in producing differences between the two groups.

At an early age girls have a higher perception and career interest in STEM compared to middle and high school girls (Bandura, 1993; Gunderson et al., 2012; Lamb et al., 2012; Osborne, 2010; Piatek-Jimenez, 2008; Wang, 2013) regardless of having been exposed to PLTW. However, middle school and high school PLTW may have an effect on perceptions and career interests. According to Sorge (2014), *A Multi-Level Analysis of Project Lead the Way Implementation in Indiana*, PLTW may have an impact on girls' interests in STEM and are statistically significant in majoring in STEM compared to boys. There may be implications that girls that have access to STEM or a thematic/integrated based education in elementary school will have an affinity towards careers in STEM, based on their perceptions, as they continue through middle and high school.

The results point out that girls in elementary school, no matter the curriculum, have positive perceptions toward STEM and career interests in STEM. Women still are outnumbered by their male counterparts, by 24% to 76% respectively, in STEM careers (Noonan, 2017). There is something to be considered as to why girls in elementary school hold perceptions in STEM and then leave the STEM pipeline as they increase in age (Blickenstaff, 2005).

This study has furthered the understanding that girls may not necessarily be influenced by STEM curriculum at the elementary level and that these participants already possess perceptions in STEM and interests in careers in STEM. This study showed that girls, regardless of being exposed to PLTW's, Launch STEM curriculum have a positive perception about STEM with an influence on their career interests.

APPENDIX A

CAREER INTEREST QUESTIONNAIRE

Career Interest Questionnaire

This survey contains three (3) brief parts. Read each statement and then mark the circle that best shows how you feel.

Lunch ID#: ________ School:___________	Use the ID number that you enter into the device during lunch. Check one ☐ Male or ☐ Female Grade: __________ Age: _________

Instructions: Select one level of agreement for each statement to show how you feel.

SD = Strong Disagree, D = Disagree, U = Undecided, A = Agree, SA = Strongly Agree

Part 1

	SD	D	U	A	SA
1. I would like to have a career in science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
2. My family is interested in science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
3. I would enjoy a career in science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
4. My family has encouraged me to study science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
5. I work hard when working on engineering and science	①	②	③	④	⑤

Part 2

	SD	D	U	A	SA
6. I will make it into a good college and major in an area needed for a career in science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
7. I will graduate with a college degree in a major in area needed for a career in science, technology, engineering **or** mathematics (STEM).	①	②	③	④	⑤
8. I will have a successful career and make a contribution to a field in science, technology, engineering **or** mathematics (STEM)	①	②	③	④	⑤
9. I will get a job in a science, technology, engineering **or** mathematics (STEM) related area.	①	②	③	④	⑤
10. Some day when I tell others about my career, they will respect me for doing work in science, technology, engineering **or** mathematics.	①	②	③	④	⑤

Part 3

	SD	D	U	A	SA
11. I would feel more comfortable talking to people who work in science or engineering careers	①	②	③	④	⑤
12. If I do well in mathematics lessons, it will help me in my future career.	①	②	③	④	⑤
13. Having a career in STEM would be fascinating and enjoyable	①	②	③	④	⑤
14. I know someone in my family that uses science, technology, engineering **or** mathematics in their career.	①	②	③	④	⑤

(Kier, Blanchard, Osborne, & Albert, 2014; Tyler - Wood, Knezek, & Christensen, 2011)

Adapted from (Kier, Blanchard, Osborne, & Albert, 2014; Tyler - Wood, Knezek, & Christensen, 2011)

APPENDIX B

SEMANTICS SURVEY

STEM Semantics Differential Survey

This five-part questionnaire is designed to assess your perceptions of scientific disciplines. I should require about 5 to 10 minutes of your time. Usually it is best to respond with your first impression, withou giving a question much though. You answers will remain confidential.

Lunch ID#: ________	Use the ID number that you enter into the device during lunch.
School:___________	Check one ☐ Male or ☐ Female Grade: _________ Age: ________

Instructions: Choose one circle between each adjective pair to indicate how you feel about the object.

To me, **SCIENCE** is:

1.	fascinating	①	②	③	④	⑤	⑥	⑦	ordinary
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, **MATH** is:

1.	boring	①	②	③	④	⑤	⑥	⑦	interesting
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	fascinating	①	②	③	④	⑤	⑥	⑦	ordinary
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot

To me, **ENGINEERING** is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	fascinating	①	②	③	④	⑤	⑥	⑦	ordinary
3.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, **TECHNOLOGY** is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
3.	boring	①	②	③	④	⑤	⑥	⑦	interesting
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	fascinating	①	②	③	④	⑤	⑥	⑦	ordinary

To me, a **CAREER** in science, technology, engineering, or mathematics (is):

1.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
2.	boring	①	②	③	④	⑤	⑥	⑦	interesting
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	fascinating	①	②	③	④	⑤	⑥	⑦	ordinary
5.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing

(Christensen et al., 2011; Knezek et al., 2012; Tyler-Wood et al., 2011; *UNT Instruments*, 2019.

APPENDIX C

CAREER INTEREST QUESTIONNAIRE SURVEY QUESTIONS

(MEASURE, INFIT, OUTFIT)

Career Interest Questionnaire Survey Questions (measure, Infit, outfit)

Q	Measure	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
11	.24	1.65	3.0	2.02	4.3
14	-.10	1.90	3.9	1.89	3.7
5	-.38	1.27	1.4	1.23	1.1
1	-.17	1.24	1.3	1.14	.8
4	-.56	1.03	.2	.89	-.5
7	-.17	.98	-.1	.88	-.6
9	.60	.95	-.2	.94	-.3
10	.16	.90	-.5	.89	-.5
3	.02	.86	-.7	.80	-1.0
13	-.22	.83	-.9	.79	-1.1
6	.39	.76	-1.4	.78	-1.2
12	.07	.48	-3.4	.74	-1.4
8	.13	.65	-2.1	.65	-2.0
2	-.01	.64	-2.2	.62	-2.2

Infit/outfit table (Bond, 2015)

APPENDIX D

SEMANTICS SURVEY QUESTIONS

(MEASURE, INFIT, OUTFIT)

Semantics Survey Questions (measure, Infit, outfit)

Q	Measure	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
10	1.31	2.80	5.7	4.16	6.9
6	-0.01	1.29	2.8	1.48	2.0
22	-0.14	1.27	1.3	1.28	1.2
8	0.32	1.26	1.5	1.17	0.9
7	0.18	1.19	1.1	1.08	0.4
11	0.02	1.18	1.0	1.08	0.4
5	0.01	1.17	0.9	1.06	0.3
12	0.05	1.13	0.7	0.97	-0.1
24	-0.06	0.71	-1.5	0.64	-1.7
21	-0.3	0.70	-1.4	0.68	-1.4
20	0.01	0.64	-2.1	0.57	-2.2
14	-0.06	0.63	-2.0	0.57	-2.1
25	-0.03	0.60	-2.3	0.54	-2.4
16	-0.34	0.54	-2.2	0.59	-1.6

Infit/outfit table (Bond, 2015) see appendix C for full infit/outfit data

APPENDIX E

CAREER INTEREST QUESTIONNAIRE SURVEY (PERSONS)

INFIT AND OUTFIT

Career Interest Questionnaire Survey Persons (measure, Infit, outfit)

Persons	Measure	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
64	1.43	3.89	4.4	4.19	4.7
7	2.43	3.17	3.8	2.92	3.5
59	-0.64	2.85	4.0	2.84	1.0
48	1.57	2.32	2.6	2.20	2.4
31	1.57	2.28	2.5	2.26	2.5
61	2.65	2.14	2.4	2.21	2.4
13	1.72	2.03	2.2	1.93	2.0
65	2.23	0.56	-1.3	0.58	-1.2
37	2.23	0.57	-1.2	0.56	-1.2
6	0.70	0.55	-1.3	0.55	-1.3
12	1.43	0.54	-1.3	0.50	-1.4
55	-0.15	0.52	-1.6	0.53	-1.6
3	2.05	0.51	-1.4	0.52	-1.4
8	1.72	0.50	-1.4	0.51	-1.4
63	-0.06	0.50	-1.7	0.50	-1.7
54	1.77	0.46	-1.5	0.47	-1.5
30	0.49	0.43	-1.8	0.45	-1.7
11	1.49	0.44	-1.6	0.42	-1.8
53	0.59	0.37	-2.1	0.39	-2.0
34	1.60	0.29	-2.3	0.31	-2.2
28	1.04	0.28	-2.5	0.29	-2.4
20	1.16	0.24	-2.7	0.24	-2.7
45	1.43	0.12	-3.6	0.13	-3.5
40	1.19	0.07	-4.0	0.06	-4.2
62	1.29	0.05	-4.6	0.05	-4.7

[Persons number is the same the participants' identification on the Variable map; where the S stands for STEM school and the N stands for non-STEM school. Then the numbered individual and the last number is their grade 4 or 5. (example S194 is the student attended the STEM school, number 19 in grade 4)]*
Infit/outfit table (Bond, 2015)

APPENDIX F

SEMANTICS SURVEY (PERSONS) INFIT AND OUTFIT

Semantics Survey Persons (measure, Infit, outfit)

Persons	Measure	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
46	-0.08	1.71	2.5	4.03	6.6
19	1.96	3.29	2.5	0.70	-0.3
26	0.21	3.29	2.5	0.70	-0.3
34	0.21	2.80	4.7	2.90	4.6
45	0.17	1.78	2.4	2.50	3.7
61	1.7	2.28	1.8	0.88	0.0
35	0.1	1.96	3.0	2.20	3.3
40	1.73	2.16	1.7	0.70	-0.4
56	0.4	1.84	2.4	1.82	2.2
42	1.43	1.79	1.2	0.60	-0.3
33	0.8	1.63	1.5	1.73	1.7
64	0.47	1.63	1.7	1.55	1.5
58	0.34	1.60	1.8	1.51	1.5
14	0.21	1.53	1.8	1.45	1.5
51	0.33	0.67	-1.2	0.68	-1.1
5	0.28	0.65	-1.4	0.67	-1.2
4	0.54	0.64	-1.0	0.65	-0.9
9	-0.13	0.62	-1.8	0.61	-1.8
21	0.92	0.53	-1.2	0.60	-0.9
44	0.49	0.59	-1.2	0.59	-1.2
28	0.18	0.58	-1.8	0.55	-1.8
1	0.29	0.55	-1.7	0.52	-1.7
49	0.97	0.52	-1.3	0.48	-1.4
3	0.31	0.51	-2.0	0.50	-2.0
20	0.40	0.45	-2.2	0.49	-1.9
10	0.93	0.34	-2.0	0.27	-2.3
12	0.20	0.25	-4.1	0.30	-3.5
27	0.46	0.27	-3.3	0.28	-3.1
15	1.05	0.27	-2.5	0.27	-2.3

Infit/outfit table (Bond, 2015)

APPENDIX G

INSTITUTIONAL REVIEW BOARD APPROVAL

---------- Forwarded message ---------
From: <mgillesp@csusb.edu>
Date: Mon, Jun 17, 2019 at 2:07 PM
Subject: IRB-FY2019-284 - Initial: IRB Full Board Approval Letter
To: <002958227@coyote.csusb.edu>, <jjesunat@csusb.edu>

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

June 17, 2019

CSUSB INSTITUTIONAL REVIEW BOARD
Full Board Review
IRB-FY2019-284
Status: Approved

Ms. Mina Blazy and Prof. Joseph Jesunathadas
COE - Doctoral Studies, COE - TeacherEduc&Foundtn TEF
California State University, San Bernardino
5500 University Parkway
San Bernardino, California 92407

Dear Mina Blazy Joseph Jesunathadas:

Your application to use human subjects, titled "THE EFFECTS OF PROJECT LEAD THE WAY LAUNCH CURRICULUM ON ELEMENTARY GIRLS' PERCEPTION AND SELF-INTERESTS IN STEM" has been reviewed and approved by the Institutional Review Board (IRB). The informed consent document submitted with your IRB application is the official version for use in your study and cannot be changes without prior IRB approval. A change in your informed consent (no matter how minor the change) requires resubmission of your protocol as amended through the Cayuse IRB system protocol change form.

Your application is approved for one year from June 16, 2019 through June 15, 2020.

Conditions of Approval:

Please submit the CITI Human Subjects Training Completion Report of all key personnel assisting you with the study by submitting a modification through the Cayuse IRB System. The training must be completed before key personnel assist you with the study.

Please note the Cayuse IRB system will notify you when your protocol is due for renewal. Ensure you file your protocol renewal and continuing review form through the Cayuse IRB system to keep your protocol current and active unless you have completed your study.

Your responsibilities as the researcher/investigator reporting to the IRB Committee include the following 4 requirements as mandated by the Code of Federal Regulations 45 CFR 46 listed below. Please note that the protocol change form and renewal form are located on the IRB website under the forms menu. Failure to notify the IRB of the above may result in disciplinary action. You are required to keep copies of the informed consent forms and data for at least three years.

You are required to notify the IRB of the following by submitting the appropriate form (modification, unanticipated/adverse event, renewal, study closure) through the online Cayuse IRB Submission System.

1. If you need to make any changes/modifications to your protocol submit a modification form as the IRB must review all changes before implementing in your study to ensure the degree of risk has not changed.
2. If any unanticipated adverse events are experienced by subjects during your research study or project.
3. If your study has not been completed submit a renewal to the IRB.
4. If you are no longer conducting the study or project submit a study closure.

Please ensure your CITI Human Subjects Training is kept up-to-date and current throughout the study.

The CSUSB IRB has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval notice does not replace any departmental or additional approvals which may be required. If you have any questions regarding the IRB decision, please contact Michael Gillespie, the IRB Compliance Officer. Mr. Michael Gillespie can be reached by phone at (909) 537-7588, by fax at (909) 537-7028, or by email at mgillesp@csusb.edu. Please include your application approval identification number (listed at the top) in all correspondence.

Best of luck with your research.

Sincerely,

Donna Garcia

Donna Garcia, Ph.D., IRB Chair
CSUSB Institutional Review Board

DG/MG

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